MARITIME CONTAINERIZED EXPORT FLOWS: SOUTH ATLANTIC AND GULF PORTS, 1974 - 1976

BY

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by

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MARITIME CONTAINERIZED EXPORT FLOWS: SOUTH ATLANTIC AND GULF PORTS, 1974 - 1976

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This study analyzes and explains the regularities of a portion of the world-wide commercial maritime container system on the basis of the principles of spatial interaction. It includes both origins and destinations of containerized export flows from the South Atlantic and Gulf coasts of the United States. The paucity of research concerning spatial patterns of maritime trade flows was the initial rationale for the study.

A time-specific agnostic cross-sectional model in the gravity framework was utilized to test the hypothesis that spatial interaction and spatial variation of a container system's flows could be explained

by a modicum of variables. It was further hypothesized that

(1) Increased use of containerization is inversely related to the distance separating trading communities;

(2) Increased use of containerization is directly related to the state of a nation's economic maturity;

(3) Increased use of containerization is directly related to the amount of a country's international maritime trade in general cargo; and

(4) Increased use of containerization is directly related to the stage of development of a nation's land transport network.

Explanation of container flow variance provided by the port-to-port regression analyses was generally low. However, they did show that, first, total commerce in maritime general cargo and, second, nautical distance separating trading ports were the best variables adding to explanation. By 1976, the situation became more complex with four of a possible six variables contributing to explanation. The most gratifying results occurred with the port-to-country models. Moderate to high amounts of explanation were achieved for four of the domestic region's major ports.

The hypothesis that certain derived variables could lead to a better understanding of international container flows proved to be true to a limited extent. Results indicated that further modeling of container flows should be directed toward individual port analyses.

If data could be acquired and could be incorporated into future models describing proximity to load centers, then the spillover effect of distribution hubs could be accounted for. Finally, endogenous factors--those which a port can directly influence--should be considered in future models.

CHAPTER ONE

THE CONTAINER SYSTEM PROBLEM

Introduction

This study analyzes and explains the regularities of a portion of the world-wide commercial maritime container system on the basis of the principles of spatial interaction. Spatial interaction may be defined as the flow of information, people or commodities from one locale to another. Complementarity, intervening opportunity and transferability are three necessary pre-conditions for the spatial interaction process (Ullman, 1956, 862-880). Two places are complementary if demand at one place can be satisfied by supply at another. However, interchange between the two areas can only take place if no source of supply or demand is interposed (intervening opportunity). If the final factor, transferability or distance between market and supply, is too great, interaction will not occur even with perfect complementarity and a lack of intervening opportunity.

A paucity of research concerning spatial patterns of maritime trade flows is the initial rationale for the study. The portion of the maritime system analyzed in this study includes both origins and destinations of international commercial maritime containerized exports from the South Atlantic and Gulf coasts of the United States. South Atlantic ports are those which are located south of the Virginia/North

Carolina border; while Gulf ports are those adjacent to the Gulf of Mexico.

A Historical Overview

Containerization and other forms of unitization have become the standard methods for transporting general cargoes across the oceans today. The object of all forms of unitization is the carriage of large quantities of heterogeneous goods from origin to destination:

(1) Without delays in transfering between modes;

(2) Without inspection or other administrative encumbrances on crossing international boundaries; and

(3) Without break of bulk until arrival at, or close to, the final destination (Couper, 1972, 147).

Although commercial maritime containers made their prominent appearance for the first time during the late 1950s, the concept of packaging goods in this manner began much earlier. The first notion of modern commercial maritime container movements appeared in an advertisement in the National Magazine in April of 1911. Lift-vans were provided by Bowling Green Storage and Van Company of New York for household goods shipped between the United States and Europe. From World War I onward, the United States Armed Forces used a small version of the container (CONEXs) for overseas shipments to insure the intact delivery of valuable and pilferable military cargoes. In 1949, John Woolam, a shipper, began packing sporting goods into a container for shipment as a single unit rather than as a consignment of individual packages (Nersesian, 1981, 92).

However, it was not until Malcolm McLean, a trucking magnate, acquired and converted two U.S. flag tankers and offered a coastal service from New York to Houston that the modern era of containerization began. In 1966, once again under the direct influence of McLean, Sea-Land commenced with a transatlantic service from New York to the European ports of Rotterdam, Bremen, and Grangemouth. Other early attempts to provide containerized services include Grace Lines' service to South America and Matson Navigation Company's service to Hawaii.

Thus, the new innovative technology in maritime transport was not adopted until nearly 50 years after its conception. Some of the principal reasons for the industry's earlier reluctance to readily accept containerization include the following:

(1) It is a capital intensive system, thus it is beyond the financial ability of many shipowners as well as entire countries;

(2) The vehicle of the industry--the ship--has a lifespan of over twenty years; therefore, new designs are utilized slowly; and

(3) It requires a sufficient general cargo volume in both directions because empty containers utilize the same shipboard space as full ones.

Nevertheless, in the last 25 years completely new concepts involving containerization and other unitized methods have taken hold world-wide.

The Mechanics of Containerized Movements

Commodity movement, a process of spatial transfer, is dependent upon factors of supply and demand. In international maritime trade, the flow of commodities occurs where the demand for transportation is

sufficient to insure the supply of both network and vehicle capacity. In international maritime trade the principal innovative general cargo transport medium is containerization.

The container revolution became a reality in the late 1960s and resulted from three factors--rapidly increasing labor costs, enormous expansion of international trade in manufactured goods, and increasing competition and lower profits in the shipping industry (Latham-Koenig, 1971, 654). During the 1960s, labor costs for packaging and stevedoring doubled, while the cost of marine equipment increased by only 50 percent. A low-cost efficient multimodal transport system became necessary because of increased international trade growth in manufactured items. Also, shipowners became more receptive to new ideas (innovations) because of increased competition and lower profits.

Containerization involves reusable boxes, usually without wheels, of a size and weight requiring the use of mechanical equipment when handled most efficiently (United Nations, 1970, 9). Most containers are standard units 8 feet in height and width and lengths in multiples of ten feet with a maximum of 60 feet (Whittaker, 1975, 113). The major exceptions to the International Standards Organization's (I.S.O.) recommended Twenty-foot Equivalent Unit (T.E.U.) are Sea-Land's 35-foot size as well as the 17-foot and 24-foot sizes used by Grace and Matson Lines. Recently, American President Lines called for bids for construction of an initial order of 733 45-foot containers (Ports and Harbors, September, 1981, 37-38). This new development has the potential of upsetting the acceptance of the standards proposed by the

I.S.O. degrading the present interchange of containers among different carriers.

Specialized containers have been designed to carry a wide variety of commodities. Some of the major container types include

(1) The covered dry container, the most common type, which is suitable for manufactured commodities shipped in cartons or bagged goods.

(2) The insulated and refrigerated container which is utilized for perishable cargoes such as meat, dairy products, fruit, etc.

(3) The top loader container which permits over-sized cargo to be loaded from the top.

(4) The bulk liquid container which allows for the carriage of wine, spirits, chemicals, oil, etc.

(5) The bulk powder container which is ideal for shipments of fertilizers, cement, etc.

(6) The bin container which handles bulk grain, coal, and similar cargoes.

(7) The skeleton container, similar to the covered dry type but without sidings, used for shipping drums, wire cable, and certain commercial vehicles (Branch, 1977, 188-189).

Although not all cargoes can be containerized, new container types will surely emerge to facilitate the carriage of goods not presently moved in containers today.

Attaining the maximum advantage of the through-goods movement (door-to-door) without renandling from point of origin (production) to

point of destination (consumption) is the principal objective of containerization (United Nations, 1970, 3). The function of a container is to ease the storage and transport of goods, to protect and preserve them during shipment, and to insure their efficient distribution (van den Burg, 1975, 3).

By the mid 1970s, containerships were operating on most of the world's major trade routes. Early carrier overcapacity on certain trade routes was caused by an artificially high level of anticipated profits, and high capital intensive investment requirements caused operational losses in the early years. The shipping industry in general and especially the containerized trade suffer from excess capacity alternating with periods of high demand. Vessel capacity responds quite slowly to changes in demand and reductions are painfully slow. In the short run, the supply of vessels is inelastic; thus, shortages of ships are reflected in upward price swings for the movement of cargo. On the other hand, voyage costs are fixed and are largely independent of the amount of cargo carried. Therefore, economic pressures often exist, in periods of excess capacity, to accept cargo at lower than usual freight rates thus causing rate wars. Future growth in containerized movements will certainly be closely tied to and adjusted by both cyclical market forces and increases in world trade (Whittaker, 1975, 303-308).

The Status of Containerization Data

The general lack of port-to-port foreign trade statistics has not changed since Darnton (1953, 11-13) called for a more orderly system of compiling such data. Yeates (1969, 399-404) suggested that spatial

interaction models are appropriate conceptualizations for meaningful research into the geography of international trade flows. The spatial interaction theme has been applied to total international trade flows between nations (Johnston, 1976), but the difficulties of obtaining port-to-port United States foreign trade data have relegated the majority of geographic maritime research to studies emphasizing site rather than situation. Site refers to local areal conditions, while situation refers to the effects of events in one area on another. Transportation flows are one process pertinent to situation. Notable research about the importance of situation in maritime geography includes those by Patton (1958), Carter (1962), and Kenyon (1970).

Since the early 1970s, the United States Maritime Administration (MARAD) has been collecting annual container statistics. Unfortunately, MARAD's publications include only aggregated container data on the essential trade route level and only report cargo volumes which pass through principal domestic and foreign ports. However, intense competition resulting from the container revolution is also experienced by medium and small ports; and their status is more precarious than that of the larger ports. The survival of small to medium regional ports will be highly dependent upon successful interport competition both among themselves as well as with the larger ports. The container revolution has permitted a rationalization of both existing vessels and ports. The number of general cargo carrying ships engaged in international trade has been reduced due to the larger size and greater efficiencies of the containership compared to the break-bulk vessel. This has resulted in container vessels concentrating their

services on fewer ports (load centers), and these line-haul ports are connected to extensive tributary areas (hinterlands). Therefore, if efforts to attract a reasonable level of cargoes are successful, the future of the small to medium regional port will be precluded resulting either in their limited use as feeder ports or even in their closure.

Research Goals

This study will differ from previous investigations since it will consider only the movement of containerized cargoes. Two distinct research goals are as follows:

(1) To monitor changes in the system between two years (1974 and 1976); and

(2) To provide a detailed quantitative breakdown of the major factors affecting a container system.

These research goals have not been addressed, evaluated, or tested either in the geographic or in the containerization literature.

Containerization is presently the dominant means by which general cargoes are transported over the world's sea routes. This dominance rests on the premise that the majority of international trade is among nations with developed economies. These nations are the primary traders. An analysis of containerized movements will contribute to further geographic understanding of transportation networks by describing and classifying empirical regularities of a segment of the United States' international trade system. This study will enhance geographic awareness of that sytem by explaining certain (regionally based) container flow patterns through time. Assuming that a

sufficient level of explanation can be achieved, the first goal of monitoring change within the system is straight-forward. Once variability is isolated, questions may be addressed as to why changes have occurred. Answers to such questions could provide addtional input thus aiding regional port planning decisions.

Container System Suppositions

Generally, the thesis of this research is that, although flows of international trade in maritime containers are dispersed world-wide, containerization will continue to be concentrated between and among industrialized economies rather than between developing economies. The working hypothesis is that spatial interaction and spatial variation of a container system's flows can be explained by a modicum of variables. More explicitly; however, it is hypothesized that

(1) Increased use of containerization is inversely related to the distance separating trading communities;

(2) Increased use of containerization is directly related to the state of a nation's economic maturity;

(3) Increased use of containerization is directly related to the amount of a country's international maritime trade in general cargo; and

(4) Increased use of containerization is directly related to the stage of development of a nation's land transport network.

The Distance Hypothesis

The first hypothesis, that containerization is inversely proportional to the distance between nodes (ports) of trading centers, is seldom discussed in the literature of containerization. This variable

seems to be avoided because container routes are considered relatively stable when compared to conventional break-bulk maritime cargo trade routes. Stability occurs because of the high capital investment required for cargo handling equipment (container cranes) in ports. Shipowners have effectively transferred the responsibility of providing cranes to the ports because without such equipment the ports cannot attract carriers and, without carriers, revenues of the ports would surely diminish.

Mention has been made of the optimum one-way voyage distance that a containership of a given size must travel to achieve economies of scale (Brotherson, 1966, 5; Latham-Koenig, 1971, 657, and, United Nations, 1970, 55). Even though containerships spend less time in port compared to conventional vessels, economies of scale are more profound on hauls of greater distances because of the diminishing relative importance of time in port as voyage length increases (Latham-Koenig, 1971, 656-657). Yet, the influence of distance as a surrogate for transport costs, on spatial interaction of individual container flows, has not been specifically addressed.

Mayer, (1973, 150) noted that more than 50 percent of the total origin-to-destination movements of cargo by conventional break-bulk methods were attributed to port costs, when a ship is either loading or discharging cargo. However, because early emphasis in containership was on speed rather than fuel economy, recently rising fuel costs have reduced this advantage of container systems somewhat. The reduction has resulted because the difference between voyage operating costs and cargo operating costs has been narrowed. By 1980, it was no longer

economical to run vessels up to 33 knots because in the prior six years bunkers (fuel oil) had risen from $18.00 per ton to $190.00 per ton (Hall, 1980, 32).

The Econometric Hypotheses

The last three of the four hypotheses emanate from readings of containerization literature, where a notion that certain characteristics can contribute to an explanation of a maritime container system is implied but never tested (Couper, 1972; London Chamber of Commerce, 1968; Meyers, 1957, 151-154; Rath, 1973; Strom, 1972, 46-57; and United Nations, 1970). The major variables allude to include

(1) well-developed economies;

(2) high degrees of industrialization and/or manufacturing;

(3) large throughputs of general cargo; and

(4) mature land transport infrastructures.

A well-developed economy influences a country's buying power, therefore, encouraging demand for diversified products and increased trade. The degree of industrialization affects the supply of the principal cargo carried in containers--manufactured goods. Large volumes of general cargo are necessary because of the high fixed capital costs for the vessel and the port. If substantial general cargo flows do not exist, a container operation will incur losses because of unused vessel capacity and space. The flows must also be balanced because transporting empty boxes generates no revenue. Finally, a mature land transport infrastructure implements one of the major goals of intermodal movements--a door-to-door operation (Port of New York Authority, 1967, 9).

The statistical hypotheses was that distance is not as important as it has been demonstrated in previous maritime studies. Nevertheless, it was expected that distance will contribute to an overall explanation of the geography of containerization. It is anticipated that the independent explanatory variables will enter the model in the following sequence:

(1) General cargo volume;

(2) Balance of maritime general cargo;

(3) Distance; and

(4) The proportion of international trade in manufactured goods.

It is further hypothesized that the remaining two variables, the level of economic development and transportation infrastructure, will not contribute significantly to the model. The latter two variables were introduced because qualitative references are made to them in the published literature (Nagorski, 1972, 65; and Sun and Bunamo, 1973, 156-162).

Summary

Approximately fifty years passed until the maritime transport industry adopted containerization as a working innovative technology. Since the late 1960s, containerization and other unitized methods have been accepted as the major forms of international maritime transportation for the carriage of general cargoes. The functions and mechanisms necessary for the performance of a maritime container system have been addressed and described.

This study monitors changes in a portion of the world-wide container system--exports from United States South Atlantic and Gulf coasts.

It also sought to provide a detailed breakdown of the major factors affecting the above container system. By utilizing several qualitative variables alluded to within the literature of containerization, the study tested the validity of statements statistically. Chapter Two defines the study's methodology, while Chapters Three and Four report descriptive and statistical analyses. The final chapter, Chapter Five, summarizes this work and provides conclusions and makes recommendations.

CHAPTER TWO

METHODOLOGY

Introduction

According to Johnston (1976, 2), the use of systems concepts in geography is relatively recent. A system may be defined as a set of interrelated elements in which each element interacts with one or more of the others. These interactions are necessary requirements for the system's function. Utilizing a modification of Klirr and Valach's general findings, in Harvey (1969, 451), three basic components for a maritime container system include

(1) A set of fixed ports which handle containers, each characterized by certain paths;

(2) A set of flows between those ports; and

(3) A set of relationships between the ports and their hinterlands and forelands.

The first two components describe the structure of a container system at a point in time, whereas the third component modulates the pattern of interaction over time. Since the primary objective of the proposed research was to explain the spatial variation of container flows, emphasis was initially directed toward the structure of a container system for an exclusive time period. Therefore, a time-specific geographic model of containerization was most suitable for the indicated problem.

The Gravity Model

The gravity model has been used successfully in geographic investigations of urban movement and international trade phenomena, among many others. Gravity and potential concepts are deterministic in nature and have been used both to discover fundamental relationships as well as to provide a basis toward the development of theories of traffic flows (Carrothers, 1956, 94). Simply stated, the gravity concept of human interaction postulates that interaction between two centers varies directly with some function of mass and inversely with some function of the distance between them (Abler, Adams, and Gould, 1971, 221-224).

Successful examples of derivations of gravity models applied to geographic research on commodity flows have been accomplished by Yeates (1968, 134-141) and Black (1972, 107-113). Hence, the gravity model framework is suggested as appropriate to analyze and explain the regularities of a maritime container system.

All characteristics on page 9 in Chapter ONE are qualitative because nowhere does the literature report them as a quantitative set. The complexities of statistically testing qualitative sets suggests that a conversion of such variables to a quantitative set is appropriate. Where data for the specific variables are unavailable, surrogate variables were sought.

A cross-sectional model, in the gravity model framework, was created to fit the empirical data to a least-squares regression

analysis. The variables in the model are as follows:

$$IVC_j = f(GNP_j, EGY_j, TCM_j, RITE_j, CVH_j, DST_j)$$

where

IVC_j was one of the following dependent variables;

$CTNX_j$ was the number of containers exported to country j from a South Atlantic or Gulf coast port of the United States; or

$TNSX_j$ was the number of tons exported in containers to country j from a South Atlantic or Gulf coast port of the United States;

GNP_j was the gross national product of country j in the respective year;

EGY_j was the energy consumption per capita of country j in the respective year, which is a surrogate for the degree of manufacturing in country j;

TCM_j was the total maritime commerce in general cargo of country j in the respective year;

$RITE_j$ was the ratio of maritime general cargo imported over that exported from country j in the respective year;

CVH_j was the number of commercial vehicles in country j in the respective year, which is a surrogate for the degree of development of the land transport infrastructure in country j; and

DST_j was the distance of the foreign port in country j from the South Atlantic or Gulf coast port of the United States.

The rationale for using two surrogate variables is that per capita energy consumption is highly correlated with the amount of

manufacturing; and the number of commercial vehicles is representative of a country's land transport infrastructure.

The function of the model is to test the hypotheses and create law-like statement(s). Each of the two models were fitted twice, once for 1974 data and again for 1976. In this manner, comparisons of both the coefficients and residuals of each equation were examined for change. Significance of estimating equations for each model was considered at $\alpha = 0.05$ for both the regression and the coefficients of the independent variables which entered the equations. Inferential statistics were utilized because the phenomena of containerized flows were examined for two discrete time periods. In fact, flows of containers are continuous; and two discrete populations are not necessarily indicative of a continuous process.

Model Assumptions

The use of assumptions is a common practice in scientific research. Assumptions simplify reality so that the research can move from the specific to the general. An analysis of the container system therefore requires the following assumptions:

(1) That no artificial boundaries or barriers restricted the movement of containers; no specific trade policies existed;

(2) That countries which were landlocked utilized the nearest adjacent maritime facility; no restrictions because of political situations were evident;

(3) That the difficulty of container movements by water was equal in all directions from any port; an equal friction of maritime distance was the case in all directions;

(4) That a uniform type of carrier or ship serviced all areas; no transport innovation affecting container carriers was introduced during the time period of the study;

(5) That the cost of transport was directly proportional to distance although a tapering rate principle existed, no special rate structures were in force; and

(6) That human decisions about location and spatial interactions reflected an underlying exigency to minimize the frictional effects of space; economic man was present.

The above assumptions are generic to most transportation problems. In the case of international trade, the assumption that no special trade policies existed eliminated such practices as most favored nation status and also trade quotas, tariffs, and embargoes. The second assumption, no restriction because of political situations, precluded the situation that a nation will have to incur unnecessary high overland transport costs. Assumption three, an equal friction of maritime distance in all directions was that, with the exception of navigating around land masses, the cost of maritime transport was equal to the distance traveled. The fourth assumption, no transport innovation affecting container carriers during the time period of the study, did not permit the use of vessels with varying sizes, speeds or capabilities; thus no cost advantages were achieved by utilizing one type of ship over another. Assumption five, no special rate structure existed, disallowed differential costs between conference liners and independents. Finally, assumption six, economic man was present,

stated that importers obtained goods from that place having the combination of the lowest production costs and least transport cost.

Hypothesis Testing

In the initial step, the null hypothesis that spatial regularities do not function within a container system was tested. Parametric statistics were used because the data were in either ratio or interval form. In these cases, parametric statistics can be applied after the data have been standardized. This permits the use of more powerful methods which increase the utility of the analysis.

The research monitored change within the system over a three-year time frame (1974 and 1976). Significant parameter estimates were utilized to develop short-term threshold values for system components. System changes, both positive and negative, can be potentially explained by advances or declines in the economic well-being of individual importing nations and the level of investment apportioned to specific domestic maritime facilities. Thus, the real effects of interport competition can be considered.

Data Collection

Dependent variable data for the container model were obtained from the United States Maritime Administration (MARAD). MARAD is the only agency currently compiling container statistics which involve port-to-port data. The agency publishes Container Cargo Statistics, an annual report which aggregates the number of containers and total tonnages on selected United States trade routes. Tonnage figures are in long tons of 2240 lbs. Disaggregated data were available on a port-to-port basis for United States exports in a MARAD unpublished report. These

disaggregated data were geocoded to identify international flows originating at South Atlantic and Gulf coast ports destined to foreign ports.

Data for the independent variables were acquired from various sources. Foreign country data pertaining to total maritime commerce and the balance of general cargo flows, as well as, per capita energy consumption, and number of commercial vehicles were extracted from the United Nations Statistical Yearbook for the appropriate year. Gross national product statistics were obtained from the Europa Yearbook. Finally, distance between United States ports and maritime facilities in foreign countries were calculated from H.O. Publication #151, Distances Between Ports.

Summary

The rationale for this study emanated from the paucity of research concerning spatial patterns of maritime trade flows--especially containerized movements. The study analyzed and explained flow patterns of commercial international container traffic exported from the United States South Atlantic and Gulf coast ports on the basis of the principles of spatial interaction.

The analysis, deterministic in nature, employed a gravity model framework to test the extent of spatial regularities in this international trade subsystem. After a significant level of explanation was achieved, change within the system was monitored over a three-year interval; and questions as to why change has occurred were addressed. Analyses of containerized movements contribute to a further geographic understanding of transportation networks. An explanation of certain,

regionally based container flow patterns through time can provide a planning tool for specific container facility improvements.

CHAPTER THREE

DESCRIPTIVE ANALYSES

Introduction

As a first step towards a better understanding of the South Atlantic-Gulf Coast's export container subsystems, descriptive analyses were performed prior to statistical analyses. These quick-scan strategies provided insights regarding the data's temporal regularities and irregularities. Analyses were performed on two levels:

(1) From the perspective of the domestic ports of origin as export forelands; and

(2) From the position of the foreign ports of destination as import forelands.

Forelands, according to geographers, are the land areas which lie on the seaward side of a port, beyond maritime space, and with which the port is connected by ocean carriers. Thus the concept of "foreland," as opposed to "hinterland," might be applied to all situations provided maritime traffic is viewed from the port (Weigend, 1958, 185-200). In this study, United States ports are export forelands to foreign ports and foreign ports are import forelands for United States ports. The following analyses include both numbers of containers and tonnage shipped for the years 1974 and 1976.

The Combined Export Ranges

A port range consists of all maritime facilities within a specifically defined geographic area. By aggregating individual ports into a port range, statements can be made regarding an entire system or sub-system of maritime facilities. Two ranges are studied here, the South Atlantic and the Gulf coast.

Over the three year study period, regional containerized exports increased in both numbers and tonnage. In the initial study year (1974), South Atlantic and Gulf Coast ports handled 94,653 containers (boxes) weighing 1,415,824 long tons (2,240 lbs.); by 1976 the volume had grown to 138,762 boxes and 2,176,236 tons. The locations of South Atlantic and Gulf ports handling export container shipment in either year of the study may be seen in Figure 1. Between 1974 and 1976 regional exports of containers increased 46.60 percent and tonnage increased 53.71 percent (See Table 1). These increases demonstrate the overall vitality of the combined port ranges. However, as would be expected, each range grew at different rates.

The Individual Export Ranges

When the performance of each range was considered individually, the South Atlantic range was clearly dominant in both years. In 1974, South Atlantic ports moved 54,526 containers or 57.61 percent of the entire region's total, and 785,078 tons or 55.45 percent of the regional total (See Table 1). By 1976, the South Atlantic range handled 88,425 containers (63.72 percent) and 1,356,736 tons (62.34 percent). The dominance of the South Atlantic range was realized when one considers that over the time-frame export containers grew by 62.17

FIGURE 1

SOUTH ATLANTIC AND GULF PORTS HANDLING CONTAINERS, 1974 AND 1976

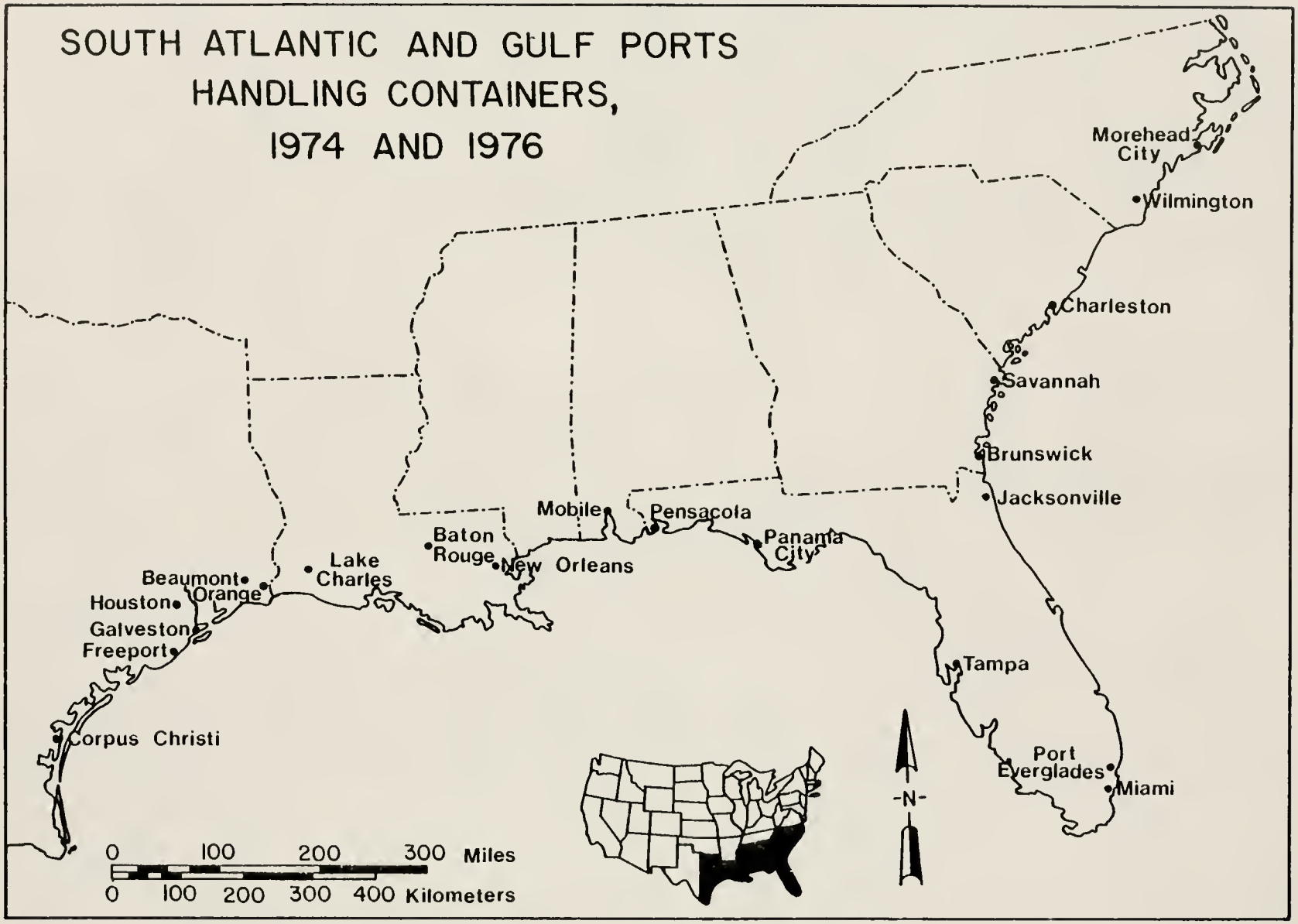
SOUTH ATLANTIC AND GULF PORTS
HANDLING CONTAINERS,
1974 AND 1976
Morehead City
Wilmington
Charleston
Savannah
Brunswick
Jacksonville
Mobile
Pensacola
Panama City
Baton Rouge
New Orleans
Lake Charles
Beaumont
Orange
Houston
Galveston
Freeport
Corpus Christi
Tampa
Port Everglades
Miami
-N-
0 100 200 300 Miles
0 100 200 300 400 Kilometers

TABLE 1

SOUTH ATLANTIC AND GULF COAST CONTAINERIZED EXPORTS,
BY PORT RANGE

RANGE	CONTAINERS		TONS	
	NUMBER	PERCENT	NUMBER	PERCENT
South Atlantic - 1974	54,526	57.61	785,078	55.45
Gulf - 1974	40,127	42.39	630,746	44.55
Total - 1974	94,653	100.00	1,415,824	100.00
South Atlantic - 1976	88,425	63.72	1,356,763	62.34
Gulf - 1976	50,337	36.28	819,500	37.66
Total - 1976	138,762	100.00	2,176,236	100.00

Source: U.S. Department of Commerce, Maritime Administration, 1974 MARAD Containerized Foreign Trade Data, (unpublished report).

U.S. Department of Commerce, Maritime Administration, 1976 MARAD Containerized Foreign Trade Data, (unpublished report).

percent and tonnage grew by 72.82 percent, while the movements for the Gulf range grew by only 25.44 and 29.93 percent respectively.

The Exporting States

Only minor disparities were revealed when container flows were evaluated on the state level. In the fundamental study year, the State of South Carolina led all states in containers exported (21,009), while the State of Louisiana led all containerized tonnage (310,572). By 1976, South Carolina was first in both categories with 20.51 percent of the region's containers and 21.93 percent of the region's tonnage (See Table 2).

With regard to containers handled in 1976, Texas replaced Louisiana which held the second position in 1974, and Florida increased two places in the standing to number three. All states, with the exceptions of Alabama and North Carolina, shipped more than 13,000 containers in 1974; and only Alabama, with 235 boxes in 1976, moved less than 12,000 export containers in that year. All states, save Alabama, handled more than 200,000 tons of containerized cargo in 1976. Alabama's relatively poor position was further illustrated with negative growth rates for both containers handled and tonnage moved during the study period, while North Carolina and Florida experienced the greatest positive growth rates.

The Exporting Ports

Figures 2 - 9 show the locations of ports by port ranges exporting containers and containerized tonnage during the two years of the study. Each figure, using proportional circles, reveals the relative importance of individual ports within each port range.

TABLE 2

SOUTH ATLANTIC AND GULF COAST CONTAINERIZED EXPORTS, BY STATE

	1974				1976			
STATE	CONTAINERS	PERCENT	TONS	PERCENT	CONTAINERS	PERCENT	TONS	PERCENT
Alabama	1,007	1.06	11,9[illegible]	0.[illegible]	235	0.17	3,948	0.18
Florida	13,713	14.49	181,[illegible]	16.[illegible]	25,587	18.44	357,359	16.4[illegible]
Georgia	15,748	16.64	[illegible]	16.60	21,990	15.85	313,463	14.40
Louisiana	20,551	21.71	310,[illegible]	21.91	23,461	16.91	402,054	18.47
North Carolina	4,061	4.29	77,2[illegible]	5.[illegible]	12,845	9.26	213,574	9.81
South Carolina	21,0[illegible]	[illegible]	[illegible]	19.3[illegible]	28,458	20.51	477,232	21.9[illegible]
Texas	18,566	19.61	[illegible]	[illegible]	26,182	18.87	408,606	18.76
Total	94,653	100.00	1,[illegible]	[illegible]	138,762	100.01	2,176,236	99.97

Source: U.S. Department of Commerce, Maritime Administration, 1974 MARAD Containerized Foreign Trade Data, (unpublished report).

U.S. Department of Commerce, Maritime Administration, 1976 MARAD Containerized Foreign Trade Data, (unpublished report).

FIGURE 2

SOUTH ATLANTIC PORTS NUMBER OF CONTAINERS EXPORTED, 1974

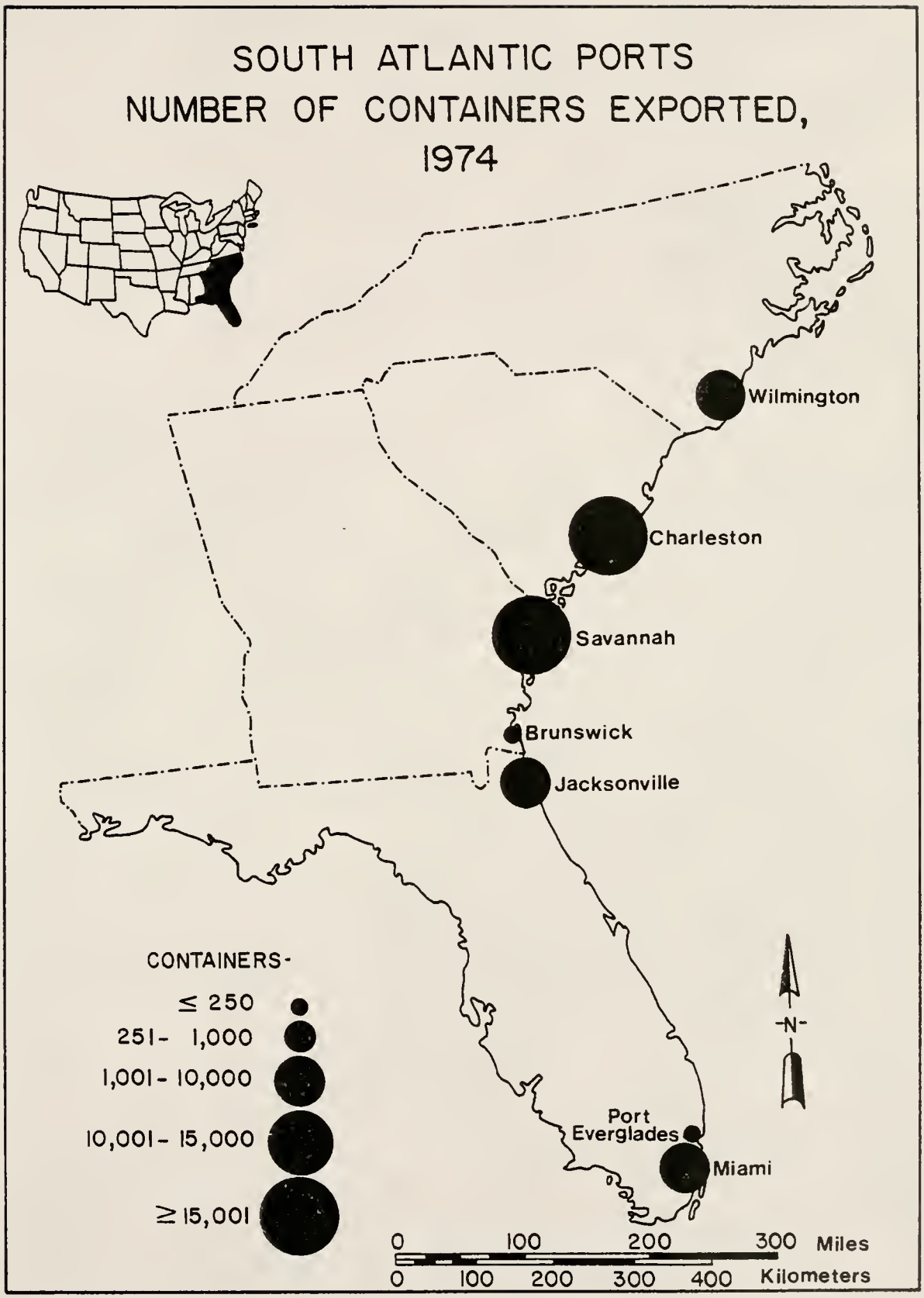
SOUTH ATLANTIC PORTS
NUMBER OF CONTAINERS EXPORTED,
1974
Wilmington
Charleston
Savannah
Brunswick
Jacksonville
Port
Everglades
Miami
CONTAINERS-
≤ 250
251- 1,000
1,001- 10,000
10,001- 15,000
≥ 15,001
-N-
0 100 200 300 Miles
0 100 200 300 400 Kilometers

FIGURE 3

SOUTH ATLANTIC PORTS LONG TONS EXPORTED, 1974

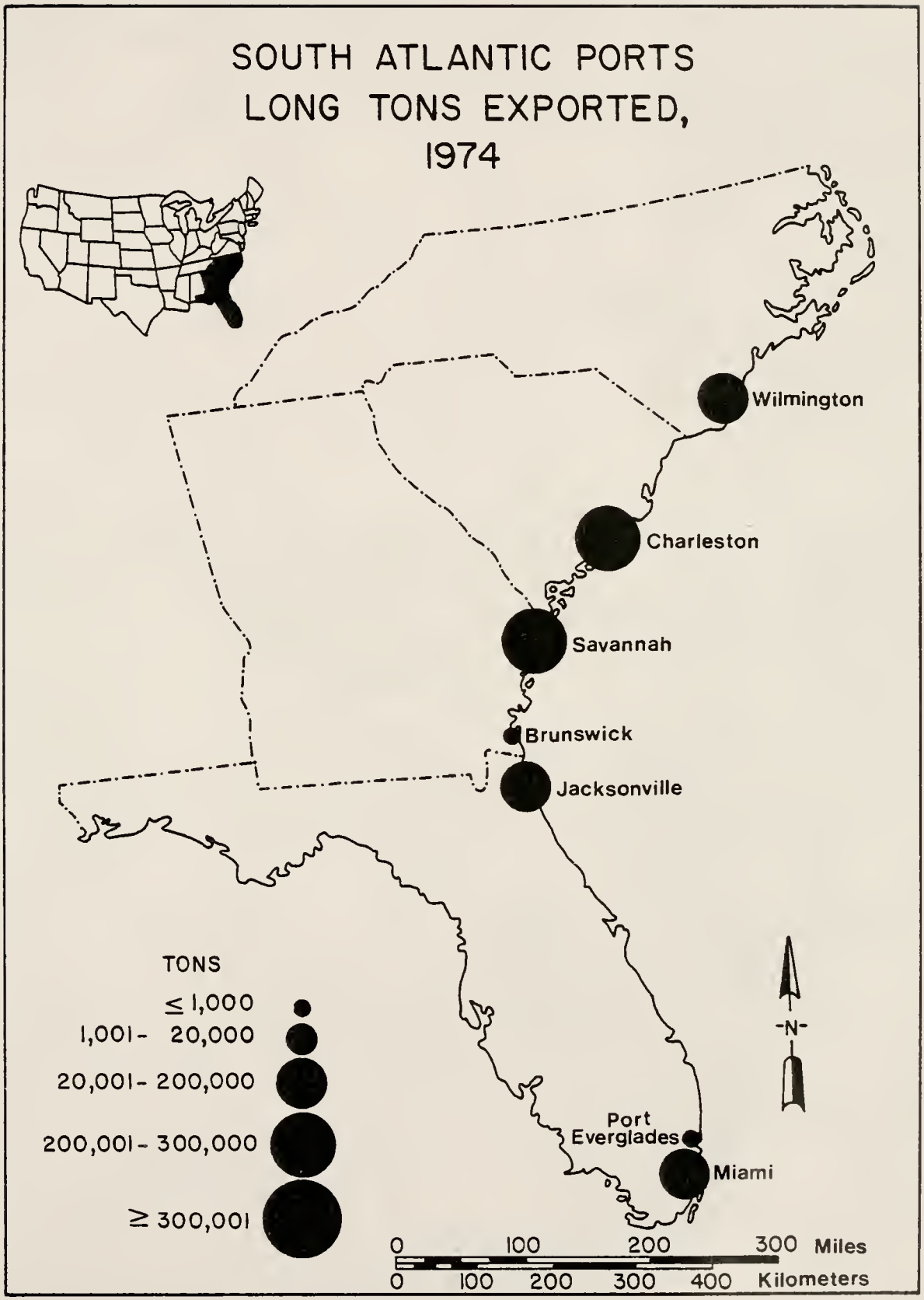
SOUTH ATLANTIC PORTS
LONG TONS EXPORTED,
1974
Wilmington
Charleston
Savannah
Brunswick
Jacksonville
Port
Everglades
Miami
TONS
≤ 1,000
1,001 - 20,000
20,001 - 200,000
200,001 - 300,000
≥ 300,001
-N-
0 100 200 300 Miles
0 100 200 300 400 Kilometers

FIGURE 4

SOUTH ATLANTIC PORTS NUMBER OF CONTAINERS EXPORTED, 1976

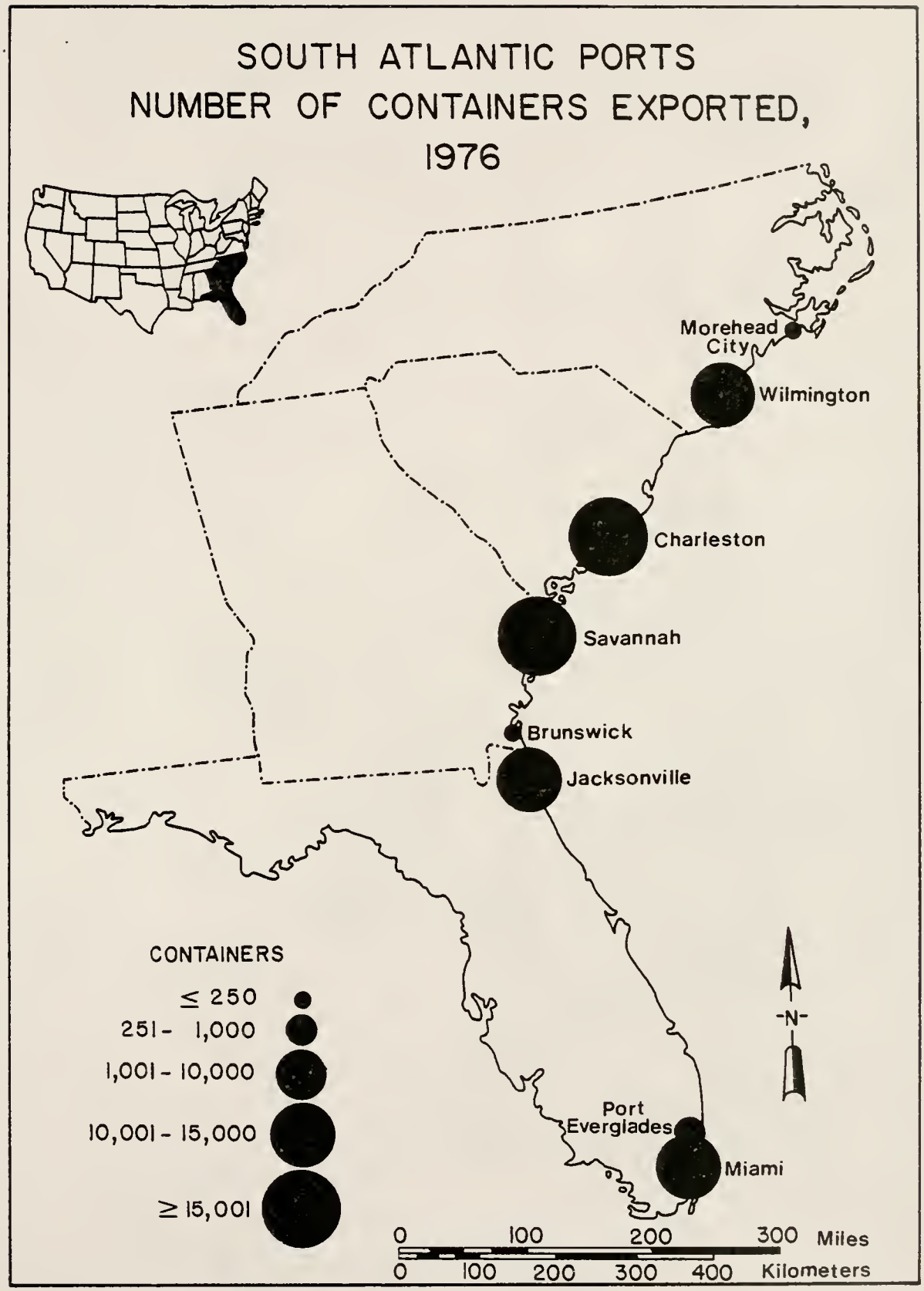
SOUTH ATLANTIC PORTS
NUMBER OF CONTAINERS EXPORTED,
1976
Morehead City
Wilmington
Charleston
Savannah
Brunswick
Jacksonville
Port Everglades
Miami
CONTAINERS
≤ 250
251 - 1,000
1,001 - 10,000
10,001 - 15,000
≥ 15,001
-N-
0 100 200 300 Miles
0 100 200 300 400 Kilometers

FIGURE 5

SOUTH ATLANTIC PORTS LONG TONS EXPORTED, 1946

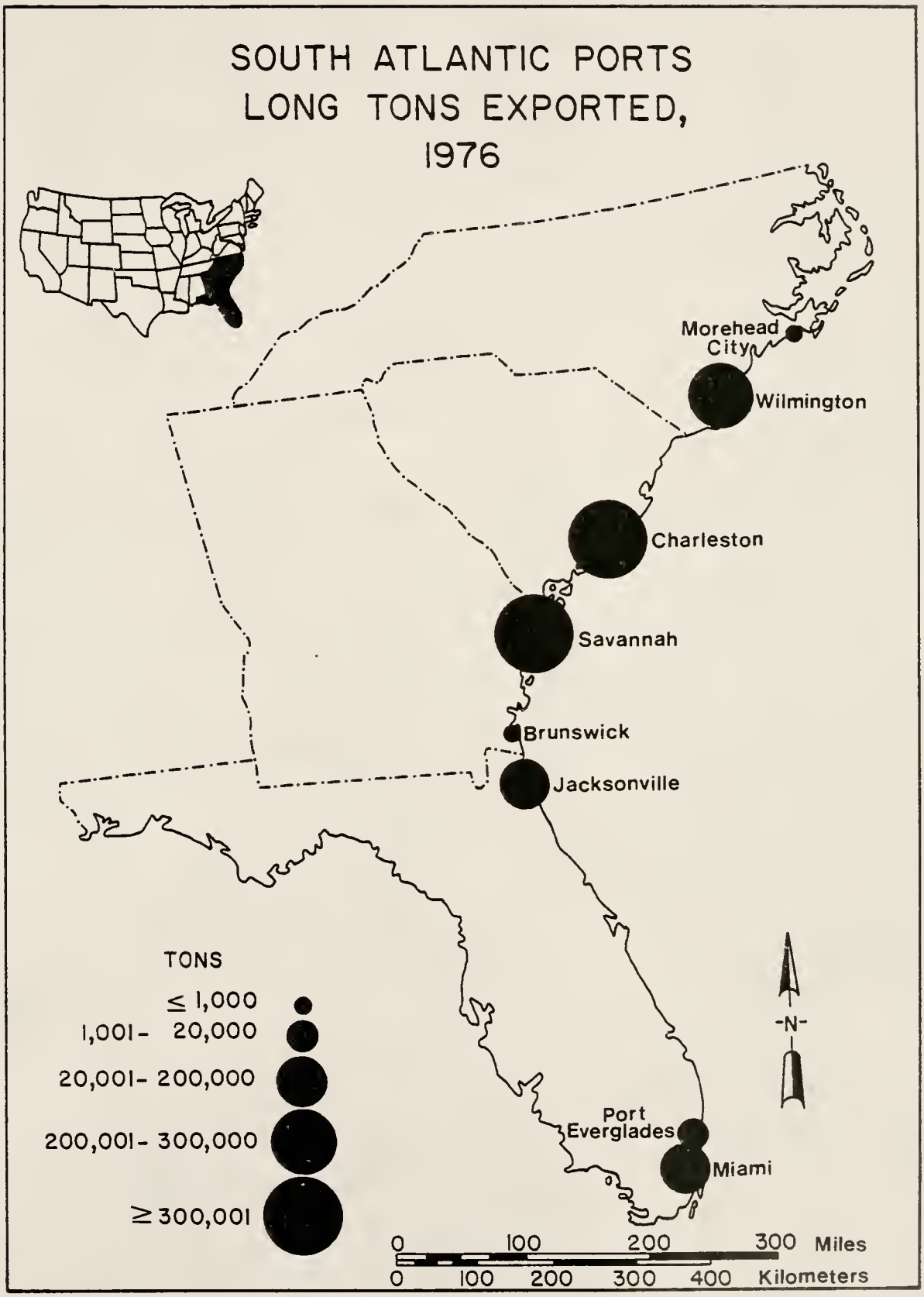
SOUTH ATLANTIC PORTS
LONG TONS EXPORTED,
1976
Morehead City
Wilmington
Charleston
Savannah
Brunswick
Jacksonville
Port Everglades
Miami
TONS
≤ 1,000
1,001- 20,000
20,001- 200,000
200,001- 300,000
≥ 300,001
-N-
0 100 200 300 Miles
0 100 200 300 400 Kilometers

FIGURE 6

GULF PORTS NUMBER OF CONTAINERS EXPORTED, 1974

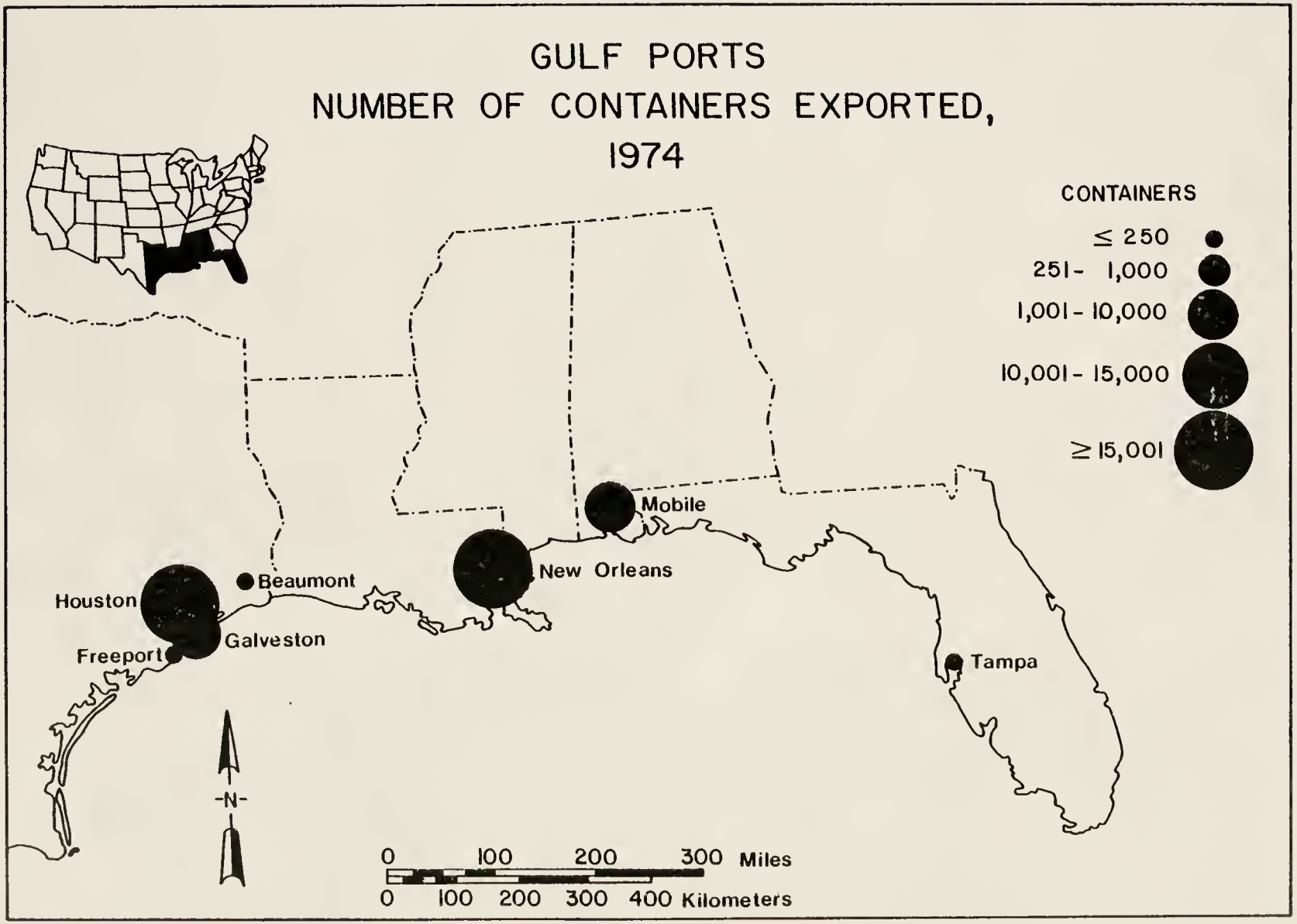
GULF PORTS
NUMBER OF CONTAINERS EXPORTED,
1974
CONTAINERS
≤ 250
251 - 1,000
1,001 - 10,000
10,001 - 15,000
≥ 15,001
Mobile
New Orleans
Beaumont
Houston
Galveston
Freeport
Tampa
-N-
0 100 200 300 Miles
0 100 200 300 400 Kilometers

FIGURE 7

GULF PORTS LONG TONS EXPORTED, 1974

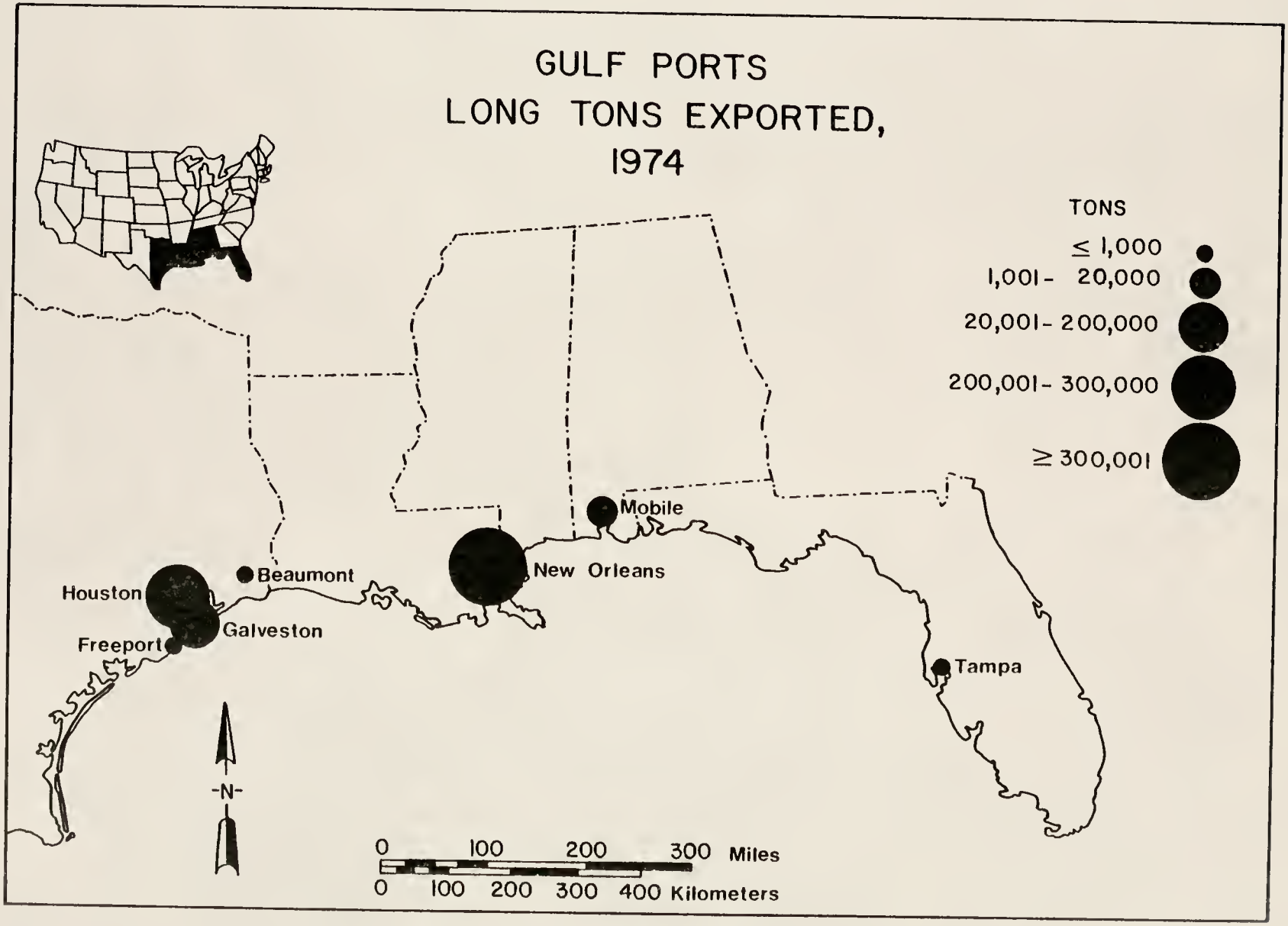
GULF PORTS
LONG TONS EXPORTED,
1974
TONS
≤ 1,000
1,001 - 20,000
20,001 - 200,000
200,001 - 300,000
≥ 300,001
Mobile
New Orleans
Beaumont
Houston
Galveston
Freeport
Tampa
-N-
0 100 200 300 Miles
0 100 200 300 400 Kilometers

FIGURE 8

GULF PORTS NUMBER OF CONTAINERS EXPORTED, 1976

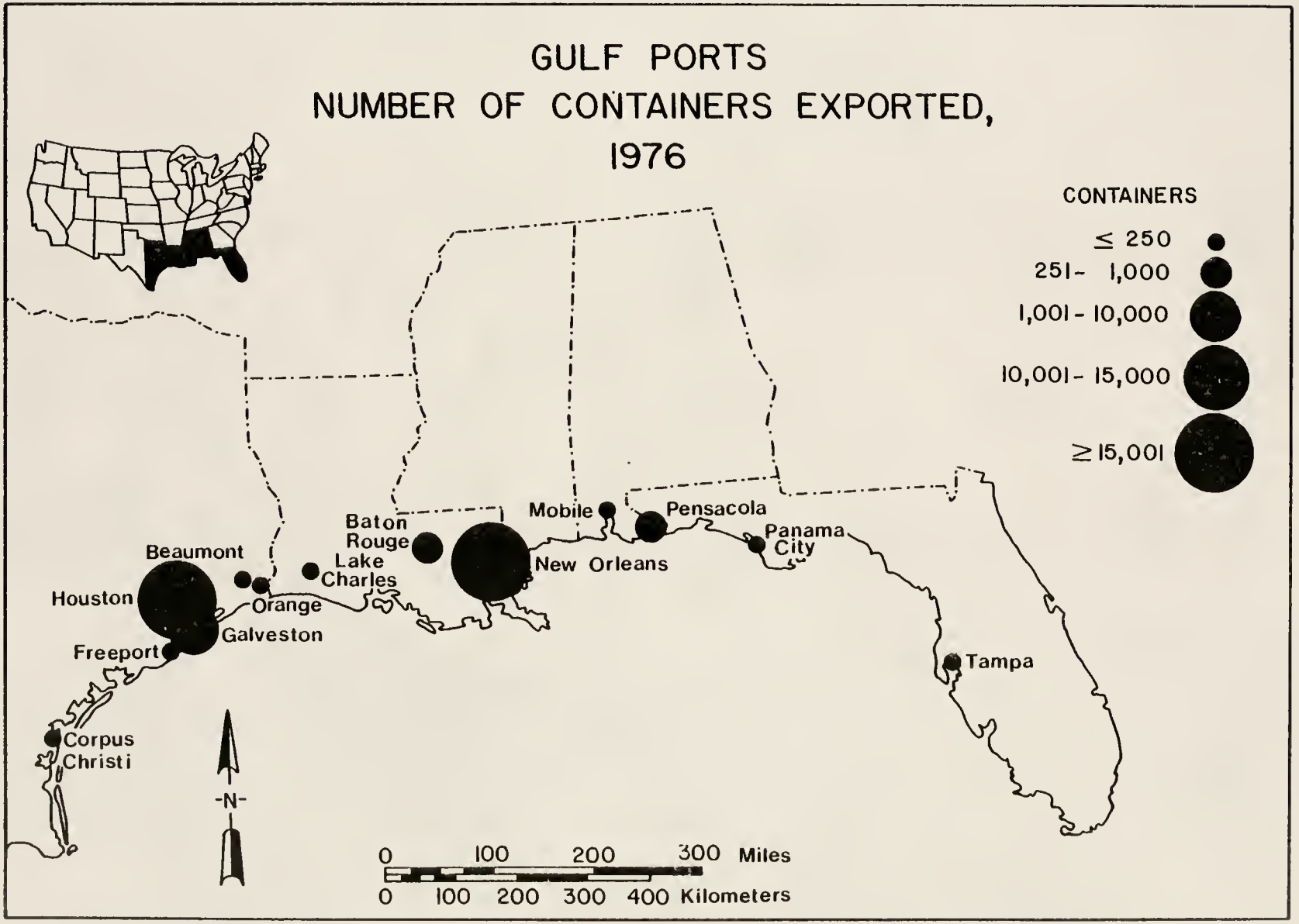
GULF PORTS
NUMBER OF CONTAINERS EXPORTED,
1976
CONTAINERS
≤ 250
251 - 1,000
1,001 - 10,000
10,001 - 15,000
≥ 15,001
Beaumont
Houston
Orange
Lake Charles
Baton Rouge
Galveston
Freeport
Corpus Christi
New Orleans
Mobile
Pensacola
Panama City
Tampa
-N-
0 100 200 300 Miles
0 100 200 300 400 Kilometers

FIGURE 9

GULF PORTS LONG TONS EXPORTED, 1976

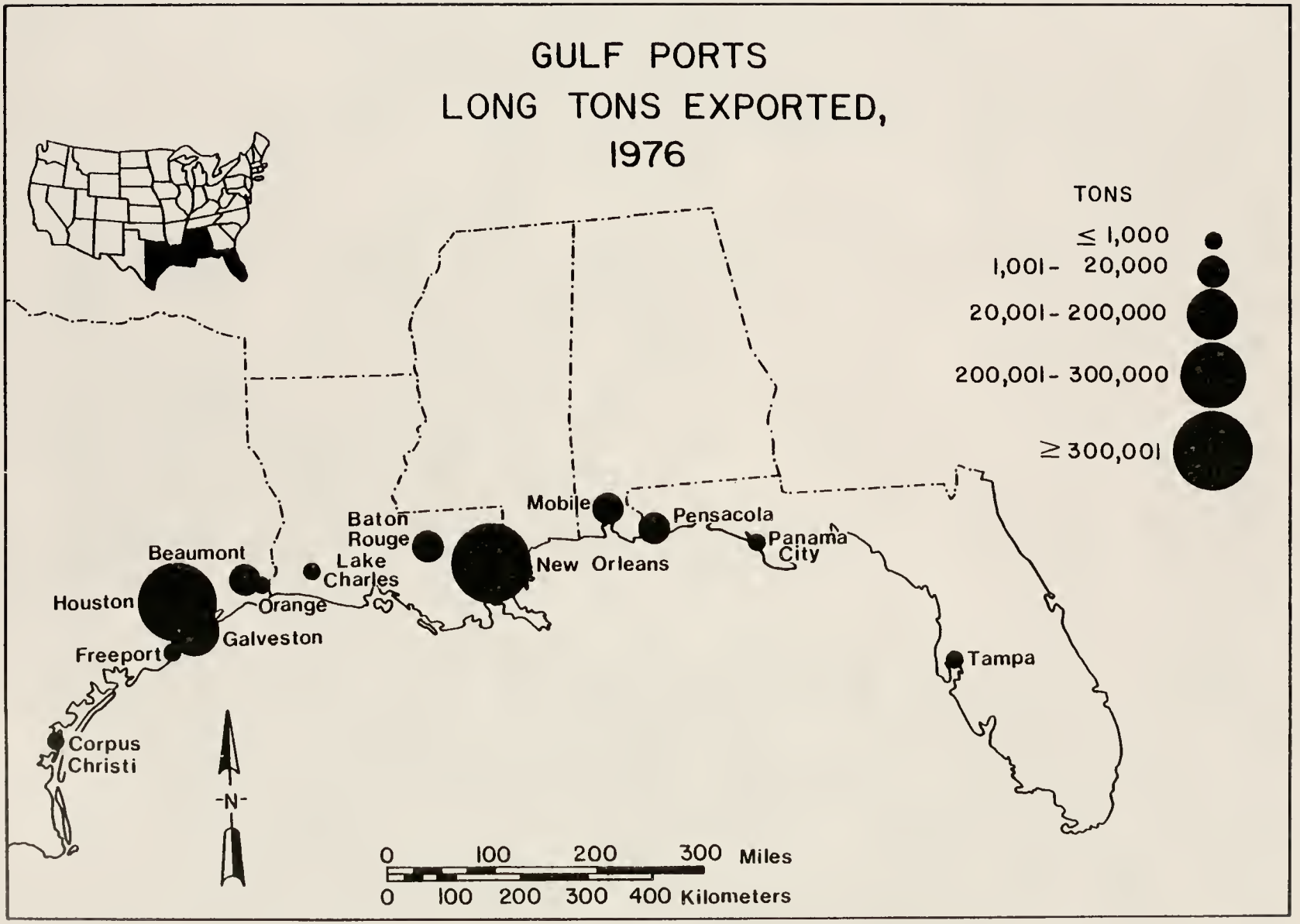
GULF PORTS
LONG TONS EXPORTED,
1976
TONS
≤ 1,000
1,001 - 20,000
20,001 - 200,000
200,001 - 300,000
≥ 300,001
Baton Rouge
Mobile
Pensacola
Panama City
Beaumont
Lake Charles
New Orleans
Houston
Orange
Galveston
Freeport
Tampa
Corpus Christi
-N-
0 100 200 300 Miles
0 100 200 300 400 Kilometers

TABLE 8

SOUTH ATLANTIC AND GULF COAST CONTAINERIZED EXPORTS, 1974, BY PORT

STATE	PORT	CONTAINERS	PERCENT	TONS	PERCENT
Alabama	Mobile	1,007	1.06	11,953	0.84
Florida	Jacksonville	4,970	5.25	71,746	5.07
	Miami	8,730	9.22	119,635	8.45
	Port Everglades	8	0.00	119	0.01
	Tampa	3	0.00	318	0.02
Georgia	Brunswick	4	0.00	30	0.00
	Savannah	15,744	16.63	235,038	16.60
Louisiana	New Orleans	20,551	21.71	310,572	21.94
North Carolina	Wilmington	4,061	4.29	77,361	5.46
South Carolina	Charleston	21,009	22.20	281,149	19.86
Texas	Beaumont	3	0.00	47	0.00
	Freeport	1	0.00	8	0.00
	Galveston	1,822	1.92	25,648	1.81
	Houston	16,740	17.69	282,200	19.93
Total		94,653	99.98	1,415,824	99.99

Source: U.S. Department of Commerce, Maritime Administration, 1974 MARAD Containerized Foreign Trade Data, (unpublished report).

Fourteen domestic ports exported containers from the region in 1974, seven from each port range (See Table 3). Individual port commerce varied from a high of just over 21,000 units to a low of only one unit, while tonnage varied from over 310,000 tons to a mere eight tons. The Port of Charleston led all other ports in containerized movements with 22.20 percent of the regional total; however, it ranked third with 19.86 percent of the tonnage.

By 1976, there were 21 ports exporting containers from the South Atlantic-Gulf region, thirteen from the Gulf and eight from the South Atlantic (See Table 4). Four ports Charleston, Houston, New Orleans, and Savannah exported more than 20,000 containers, while at the lower end of the spectrum the Port of Orange, Texas, handled only two containers. Five ports, Charleston, New Orleans, Houston, Savannah, and Wilmington moved more than 200,000 tons, while the Port of Panama City handled only nine tons.

Within the study period, the ports of Wilmington, Charleston, Houston, and Savannah experienced an absolute growth in containers greater than 5,000 units. With regard to absolute growth in tonnage handled, Charleston, Wilmington, Jacksonville, Houston, Savannah, and New Orleans all increased their handle by more than 75,000 tons.

When the data were viewed by combining the five principal ports, with respect to containers in particular years, the major ports handled 87.45 percent of the containers in 1974 and 79.14 percent in 1976. Utilizing the same methodology for tonnage, the five major ports moved 86.78 percent of the tonnage in 1974 and 80.84 percent in 1976.

TABLE 7

SOUTH ATLANTIC AND GULF COAST CONTAINERIZED EXPORTS, 1976, BY PORT

STATE	PORT	CONTAINERS	PERCENT	TONS	PERCENT
Alabama	Mobile	235	0.17	3,948	0.18
Florida	Jacksonville	10,642	7.67	165,969	7.63
	Miami	13,497	9.73	178,743	8.21
	Panama City	3	0.00	9	0.00
	Pensacola	428	0.31	4,573	0.21
	Port Everglades	993	0.72	7,755	0.36
	Tampa	24	0.02	310	0.01
Georgia	Brunswick	88	0.06	814	0.04
	Savannah	21,902	15.78	312,649	14.37
Louisiana	Baton Rouge	924	0.67	14,579	0.67
	Lake Charles	4	0.00	72	0.00
	New Orleans	22,533	16.24	387,403	17.80
North Carolina	Morehead City	15	0.01	161	0.01
	Wilmington	12,830	9.25	213,413	9.81
South Carolina	Charleston	28,458	20.51	477,232	21.93
Texas	Beaumont	82	0.06	1,071	0.05
	Corpus Christi	4	0.00	53	0.00
	Freeport	38	0.03	520	0.02
	Galveston	2,643	1.90	38,588	1.77
	Houston	23,417	16.88	368,362	16.93
	Orange	2	0.00	12	0.00
Total		138,762	100.01	2,176,236	100.00

Source: U.S. Department of Commerce, Maritime Administration, 1976 MARAD Containerized Foreign Trade Data, (unpublished report).

Although the combined major port percentages of containers and tonnage declined from 1974 to 1976, the continued dominance of these ports indicated and reflected the initial development of load centers throughout the region. Ports handling minor amounts of containerized cargo in the region were serviced by conventional carriers rather than container vessels and such cargoes most generally are moved on the decks of such vessels.

The Importing Countries

Appendix A lists the relevant data by country for containers and tonnage during 1974 and 1976. The South Atlantic-Gulf region exported containers to 85 different countries during the study period, 64 in 1974 and 74 in 1976. By country, containers ranged from 1 to 33,291 in 1974 and from 1 to 48,129 in 1976. Tonnage, by country, ranged from 5 to 455,800 in the former year and from 7 to 791,185 in the latter year.

The Netherlands, in both years, led all countries importing containers and containerized tonnage with 32 percent or more of the total cargo imported from the two United States port ranges (See Table 5). The top ten importing nations included Australia and countries in Europe, Asia, and South America. In each year, five of the top ten countries were in Europe indicating that region's affinity for importing from the South Atlantic-Gulf region. In total, the top ten importing countries handled 87.0 percent of the domestic ranges' containers in 1974 and 88.9 percent in 1976, while tonnage stood at 81.0 percent in 1974 and grew to 82.4 percent in 1976. Thus it was

TABLE 5

TOP TEN COUNTRIES RECEIVING CONTAINERIZED IMPORTS
FROM SOUTH ATLANTIC AND GULF PORTS,
1974 AND 1976

1974

RANK	COUNTRY	PERCENT OF CONTAINERS	RANK	COUNTRY	PERCENT OF TONS
1	Netherlands	35.9	1	Netherlands	32.2
2	West Germany	13.1	2	West Germany	20.6
3	Japan	10.5	3	Japan	11.9
4	United Kingdom	7.2	4	United Kingdom	8.5
5	Australia	4.3	5	France	4.2
6	France	3.3	6	Australia	3.2
7	Honduras	2.9	7	Honduras	3.0
8	Brazil	2.4	8	Brazil	2.5
9	Bermuda	1.7	9	Italy	1.4
10	Italy	1.4	10	Costa Rica	1.4
	Total	87.0		Total	88.9

1976

RANK	COUNTRY	PERCENT OF CONTAINERS	RANK	COUNTRY	PERCENT OF TONS
1	Netherlands	34.7	1	Netherlands	36.4
2	West Germany	14.5	2	West Germany	14.2
3	Japan	8.9	3	Japan	9.2
4	France	4.2	4	Italy	4.8
5	Italy	4.1	5	France	4.3
6	United Kingdom	4.0	6	United Kingdom	4.1
7	Australia	3.1	7	Hong Kong	2.9
8	Hong Kong	3.0	8	Australia	2.6
9	Venezuela	2.6	9	Spain	2.0
10	Spain	1.9	10	Venezuela	1.9
	Total	81.0		Total	82.4

Source: U.S. Department of Commerce, Maritime Administration, 1974 MARAD Containerized Foreign Trade Data, (unpublished report).

U.S. Department of Commerce, Maritime Administration, 1976 MARAD Containerized Foreign Trade Data, (unpublished report).

clear that containerized exports from the domestic ranges showed slight tendencies of concentration at foreign ports.

The Importing Ports

Appendix B lists pertinent data by port for containers and tonnage during 1974 and 1976. The South Atlantic-Gulf region exported containers to 184 different foreign ports during the study period, 133 in 1974 and 154 in 1976. By foreign port, containers ranged from 1 to 32,821 in 1974 and from 1 to 48,125 in 1976. Containerized tonnage, by port, ranged from 3 to 449,082 in the former year and from 3 to 791,131 in the latter year. The Port of Rotterdam in the Netherlands, for each year studied, led all foreign ports importing containers and containerized tonnage with 31.5 percent or more of the total cargo exported from the two United States port ranges (See Table 6). After Rotterdam, the only foreign port which handled more than 10.0 percent of the South Atlantic-Gulf region's containerized exports was the Port of Bremerhaven, West Germany. Similar to the results when disaggregated by country, exports to the top ten foreign ports also included ports in Australia and countries of Europe, Asia, and South America. Once again, the predominance of European markets, especially those on the North Sea, comprised the majority of imports from the South Atlantic-Gulf region although growth had occurred in both the Asia and Latin American markets. In total, the top ten importing ports handled 76.6 percent of the domestic ranges' containers in 1974 and 69.6 percent in 1976, while tonnage stood at 81.0 percent in 1974 and declined to 71.7 percent in 1976. The declines in both containers and

TABLE 6

CONTAINERIZED IMPORTS BY PORT
FROM SOUTH ATLANTIC AND GULF PORT RANGES, 1974 AND 1976

1974

RANK	PORT/COUNTRY	PERCENT OF CONTAINERS	RANK	PORT/COUNTRY	PERCENT OF TONS
1	Rotterdam, Neth.	34.7	1	Rotterdam, Neth.	31.5
2	Bremerhaven, F.R.G.	17.0	2	Bremerhaven, F.R.G.	20.0
3	Greenock, Scot.	5.7	3	Greenock, Scot.	7.1
4	Kobe, Jap.	4.7	4	Kobe, Jap.	5.2
5	Tokyo, Jap.	4.1	5	Tokyo, Jap.	4.?
6	Le Havre, Fr.	3.3	6	Le Havre, Fr.	4.1
7	Puerto Cortez, Hon.	2.9	7	Puerto Cortez, Hon.	2.8
8	Melbourne, Austrl.	2.2	8	Santos, Braz.	2.2
9	Santos, Braz.	2.1	9	Yokohama, Jap.	1.7
10	Sydney, Austrl.	1.9	10	Melbourne, Austrl.	1.6
	Total	78.5		Total	81.0

1976

RANK	PORT/COUNTRY	PERCENT OF CONTAINERS	RANK	PORT/COUNTRY	PERCENT OF TONS
1	Rotterdam, Neth.	34.7	1	Rotterdam, Neth.	36.4
2	Bremerhaven, F.R.G.	12.6	2	Bremerhaven, F.R.G.	12.4
3	Tokyo, Jap.	4.2	3	Tokyo, Jap.	4.4
4	Le Havre, Fr.	3.9	4	Le Havre, Fr.	4.0
5	Kobe, Jap.	3.1	5	Livorno, It.	3.2
6	Hong Kong, H.K.	3.0	6	Hong Kong, H.K.	2.9
7	Livorno, It.	2.6	7	Kobe, Jap.	2.8
8	Greenock, Scot.	2.0	8	Greenock, Scot.	2.2
9	La Guaira, Ven.	1.8	9	Puerto Cortez, Hon.	1.8
10	Puerto Cortez, Hon.	1.7	10	Hamburg, F.R.G.	1.6
	Total	69.6		Total	71.7

Source: U.S. Department of Commerce, Maritime Administration, 1974 MARAD Containerized Foreign Trade Data, (unpublished report).

U.S. Department of Commerce, Maritime Administration, 1976 MARAD Containerized Foreign Trade Data, (unpublished report).

tonnage showed some diversification in commerce; however, the load center concept was still readily apparent.

Summary

Container export data from United States South Atlantic and Gulf ports experienced a growth period from 1974 through 1976. The data included many large movements handled on containerships as well as many smaller numbers moved on conventional vessels.

The South Atlantic range handled the majority of the regional movements and sustained a greater absolute growth rate compared to the Gulf range. With regard to individual domestic regional ports, only Mobile, Alabama, declined in both numbers and tonnage of container cargoes. Tampa, Florida, also showed a slight loss in tonnage. The beginnings of load centers in both domestic ranges were identified.

As for the importing areas, there was also great variation in both number of boxes and tonnage. The Netherlands, with the Port of Rotterdam, was clearly the dominant destination for imports originating at the two United States ranges. On the country level, the top ten nations revealed moderate growth indicating a concentration of destinations for U.S. exports, while on the port level other than the two principal importing centers diversification occurred. However, the import markets continued to grow as evidenced by increasing acceptance of South Atlantic and Gulf exports.

CHAPTER FOUR

STATISTICAL ANALYSES

Introduction

Prior to the actual statistical analyses and modeling, it became necessary to geocode all flow data to facilitate the investigation. Worldwide Geographic Location Codes (1972), published by the General Services Administration, was utilized for this purpose. If a domestic or foreign port city was not included within the volume, then an original four-digit code was assigned to that geographic locale. Appendixes C and D contain the codes used for domestic states and port cities and foreign countries and port cities. Thus, each origin or destination of a container movement was allotted a unique numerical designation.

Next, the mileage between ports handling containers was computed using the U.S. Navy's edition of Distance Between Ports (1965). This work includes nautical distances between major world trading ports, and also distances between minor ports and maritime junction points--straits, islands, capes and major ports. The determination of the distance between facilities handling containers assumed the shortest all-water route between ports of loading and ports of discharge.

Also, each foreign trading partner's Gross National Product was obtained for each year of the study. Finally, the energy per capita consumption, the total commerce in general cargo, the ratio of maritime general cargo imported over that exported, and the number of

commercial vehicles for each foreign country handling containers was obtained from The United Nations Statistical Yearbook (1975 and 1977).

The data analyzed included all containerized exports from the South Atlantic-Gulf region with the exception of those to Taiwan and those to centrally planned economies. Data for Taiwan were excluded because socioeconomic statistics for that nation are not included in the U.N. Statistical Yearbook. Those for communist nations belonging to the Council of Mutual Economic Assistance, formerly "Comecon," except for Poland, were excluded because high proportions of their trade involves other non-freemarket economies, thus contributing trade bias into the models. In fact, Poland differs from other "Comecon" nations since it receives most favored nation (MFN) treatment from the United States and, therefore, does not pay very high tariff rates.

The Gravity/Regression Model

Variations of the basic gravity model can be used as a framework for studying spatial interaction in general. An excellent historical review of the use of gravity models can be found in an article by Carrothers (1956, 94-102). However, most geographic texts, with the exception of King (1969), Taylor (1977), and Yeates (1968), have failed to address or test the assumptions of linear regression models when they are utilized to estimate gravity parameters. The classic essay regarding the assumptions of the linear regression model was written in 1971 by Poole and O'Farrell. It will be drawn upon to assess the validity and reliability of this statistical technique as it applies to containerized export movements.

The classical linear regression model may be represented as

$$Y = a + b_i X_i + u$$

where

(1) Y is the dependent variable;

(2) $X_1, X_2, \ldots, X_i, \ldots, X_k$ are independent variables;

(3) a and b_i are the regression coefficients, which represent the parameters for a specific population; and

(4) u is a stocastic disturbance-term, which may be interpreted as resulting from the effects of unspecified independent variables and/or a totally random element in the relationship specified.

Two distinct models exist because of the nature of the independent variables. In one model, the fixed-X model, independent variables are held constant experimentally at certain fixed values, while in the random-X model values are selected at random. The "fixed-X" model will be utilized in this study.

The research objectives for which the regression model may be employed are generally classified into three groups:

(1) The computation of point estimates;

(2) The derivation of interval estimates; and

(3) The testing of hypotheses.

Although testing of hypotheses is the major concern of this dissertation, the computation of point estimates is fundamental when comparing the estimating equations for the two study years.

The critical assumptions of the linear regression model include (Poole and O'Farrell, 1971, 145-158):

(1) Each value of X_i and of Y is observed without measurement error;

(2) The relationships between Y and each of the independent variables X_i are linear in the parameters of the specific functional form chosen;

(3) Each conditional distribution of u has a mean of zero;

(4) The values of u are serially independent;

(5) The variance of the conditional distribution of u is a constant for all such distributions;

(6) The independent variables X_i are linearly independent of each other; and

(7) The fixed-X model requires that the conditional term must be normal in form.

These assumptions, as they apply to the container estimating equations, are addressed in later sections.

Regression analyses were performed on four levels, for both years of the study, and included both number of containers and tonnage. First, estimating equations were obtained for all containerized movements from the South Atlantic-Gulf coast region which included point-to-point movements. Second, equations were acquired for the two subregions individually utilizing the same criteria. Third, the data were aggregated to the foreign country level and then the regressions were performed for the entire regional area. Finally, the aggregated

data were partitioned into individual exporting ports and regression analyses were accomplished for five of the major U.S. port facilities.

Procedure

In the case of this study, all data were derived from secondary sources. Thus, the first assumption of no measurement errors cannot be satisfied without reservation. However, if measurement error indeed did exist in the dependent variables, one can still assume that they were random and incorporated in the residual error term. Also, an optimistic viewpoint was taken by assuming that any existing unknown measurement error did not prejudice the analysis.

The normal convention of linearizing gravity functions, by converting both sides of each estimating equation to logarithms, was accomplished for each regression formula. In the first series of equations, all variables were transformed into standard Z-scores. Standardized values for each observation in each distribution were obtained by subtracting its mean and dividing the result by the standard deviation of each distribution. In this manner, the Y-intercept of each regression equation becomes zero. Assumptions regarding the patterns of disturbances were discussed only for the final two series of equations since they provided the most explanation.

The last assumption, that the independent variables were linearly independent of each other, assures that multicollinearity did not exist. To assure that such a condition did not go unnoticed, Pearson correlation coefficients were examined prior to the regression analyses. Variables with acute correlations were not omitted in this study because the primary objective of the analyses was the evaluation of

statements implied within the literature--thus hypothesis testing. If highly correlated independent variables happened to enter individual equations at statistically significant levels, such variables were identified, thereby ensuring that possibly spurious results would be recognized.

A stepwise regression procedure was utilized instead of calibrating a single regression equation using all independent variables suggested. This approach begins with a bivariate equation and proceeds by adding one variable at a time until the complete equation is finally calibrated. Therefore, the order in which the variables entered the regression sequence was not arbitrary. Indeed, it was dependent upon each variable's contribution to the explanation of the unexplained variance remaining in the dependent variables for each equation. Therefore, one of the important properties of the stepwise procedure is that variables which are multicollinear with previously entered variables are less likely to enter the regression equation at a statistically significant level.

Estimating equations were considered at only the 0.05 alpha level for both the regression and the coefficients of the independent variables. Nevertheless, the signs of non-significant independent variables were evaluated. This was deemed necessary to appraise the direction of the relationships of all specified variables suggested by the literature. Thus, additional information, although not statistically significant, was gained.

Gravity/Regression Analysis

Six independent variables were regressed upon each dependent variable--first the number of containers exported (NCTNX) and secondly number of tons exported (NTNSX). The independent variables included:

DST = nautical distance between ports

TCM = total commerce in general maritime cargo for the importing country;

RITE = the ratio of general maritime cargo imported by to that exported by the foreign country;

EGY = per capita energy consumption of the importing country;

GNP = gross national product of the importing country; and

CVH = number of commercial vehicles in importing country.

The above six independent variables were utilized in all subsequent regressions.

The basic model was expressed as

$$IVC_j = B_o \, TCM_j^{B1} \cdot RITE_j^{B2} \cdot GNP_j^{B3} \cdot EGY_j^{B4} \cdot CVH_j^{B5} / DST_{ij}^{B6}$$

The B represent the relative importance of each independent variable in explaining the volume of containerized exports through the South Atlantic-Gulf coast region. To express the equation in linear form, natural logarithms of all variables were taken which yielded the following estimating equation:

$$IVC_j = \log B_o + B_1 \log TCM + B_2 \log RITE + B_3 \log GNP + B_4 \log EGY + B_5 \log CVH - B_6 \log DST$$

Following the above procedure, gravity models for number of containers and number of tons were estimated using MARAD and other derived data.

Regression Analyses South Atlantic-Gulf Coast, 1974

The results for the 335 observations in 1974 were:

$$\log NCTNX = \underset{(24.91)}{-0.28 \log DST} + \underset{(27.60)}{0.30 \log TCM}$$

$R = 0.32 \quad \bar{R}^2 = 0.10 \quad F = 19.00$

and

$$\log NTNSX = \underset{(25.89)}{-0.28 \log DST} + \underset{(38.60)}{0.35 \log TCM}$$

$R = 0.35 \quad \bar{R}^2 = 0.12 \quad F = 23.59$

where R is the multiple correlation coefficient, $\bar{R}^2$ is the coefficient of determination adjusted for degrees of freedom, and F is the ratio of explained to unexplained variance. F-ratios are written in parentheses below the coefficients. The above equations as well as those to follow are significant for the regression and the coefficients at the 0.05 level of error (two tail) or better.

The 1974 regression equations for the entire export region explained only a modest amount of the variance in the dependent variables--ten percent and twelve percent respectively. Only two of the designated six independent variables, total commerce in maritime general cargo and nautical distance, were statistically significant. The volume of general cargo handled at foreign countries was clearly the most important determinant of containerized commerce exported through the South Atlantic-Gulf region. This supports the premise

that nations which received large quantities of general cargo usually have adopted containerization as the innovative method for moving such cargo. Nautical distance, as expected, was inversely related to both the number of containers and tonnage. This inverse relationship confirms the negative effects of overcoming the friction of distance endemic to transport problems.

An analysis of residuals could lead to the development of new explanatory variables not mentioned within the existing container literature. Examination of the residuals revealed that the majority of those residuals greater than 1.5 were those of the primary world ports, i.e., Rotterdam, Bremerhaven, Hong Kong, and Singapore, for example. On the other hand, over-prediction was generally the rule for secondary world ports as well as those in developing economies, i.e., Stockholm, Belfast, and Genoa, and Hamilton, Maricaibo, and Fortaleza. For the purpose of this study developing economies are those which possessed less than two times the world average per capita GNP in each respective year. Thus, it may be deduced that the model performs poorly with regard to well-established container ports which in addition perform the service of load centers and, also, for some foreign national ports in which the predominant trade was non-containerizable traffic.

Regression Analyses South Atlantic-Gulf Coast, 1976

The estimating equations for the 488 observations in 1976 were

$$\log NCTNX = \underset{(17.36)}{-0.19}\log DST + \underset{(11.69)}{0.30}\log GNP + \underset{(3.70)}{0.15}\log EGY - \underset{(4.67)}{0.19}\log CVH$$

$R = 0.33 \quad \bar{R}^2 = 0.10 \quad F = 14.45$

and

$$\log NTNSX = \underset{(14.31)}{-0.17}\log DST + \underset{(12.99)}{0.32}\log GNP + \underset{(12.31)}{0.18}\log EGY - \underset{(5.31)}{0.20}\log CVH$$

$R = 0.33 \quad \bar{R}^2 = 0.10 \quad F = 14.45$

Four variables of a possible six entered each of the preceding equations at a statistically significant level. They included nautical distance, gross national product, energy consumption per capita, and number of commercial vehicles. However, explanation ($\bar{R}^2$) was considered to be poor. Nautical distance contributed the most toward explanation because by 1976 the principal container routes between the U.S. and Europe and the U.S. and Japan were in place. Distances between these nations and the U.S. are generally within the mid-range of containerized movements (5,000 to 10,000 miles). Also, by 1976 containerized trade was established primarily between the industrialized well-developed economies; therefore, the positive signs of the coefficients of both GNP and EGY were expected. The last variable to enter at a significant level, number of commercial vehicles, had an inverse relationship. This occurred for one or more of the following reasons:

(1) The small relative geographic size of U.S. trading partners handling large amounts of containerized trade needed only small fleets of land-based commercial vehicles.

(2) Trade with foreign load centers in both Europe and the Far East contributed to under utilization of motor trucking in favor of movements by coastal or inland waterways.

(3) The heavy use of unit trains, especially in continental Europe, captured potential containerized motor trucking movements.

(4) Although international maritime containerized movements were large, many containers were still being stripped (emptied) and stuffed (filled) within the confines of port facilities world-wide, thus eliminating door-to-door shipments.

A cursory examination of the residuals showed that residuals greater than 1.5 appeared for developing nation s ports and secondary ports of developed economies. Once again, the model performed poorly for established container ports and also for conventional ports handling few containers.

A Comparison of the South Atlantic-Gulf Coast Region, 1974 and 1976

A reexamination of the regression analyses for each year revealed that over ten percent explanation was achieved in each year. However, the individual models should not be considered to be robust since only a minor amount of explanation was accomplished. Nevertheless, some important changes and generalities occurred within the system during the three year period.

In 1974, nautical distance and maritime commerce were statistically significant, but by 1976 in addition to distance, gross national product, energy consumption per capita, and number of commercial vehicles contributed to explanation. The equations for the earlier year described an early growth period under a scenario where many nations were reluctant to adopt containerization and its high fixed capital costs. The later equations described an increasingly mature

system reflecting increased containerized trade between and among the industrialized nations of the world.

When the estimating equations for both years were carried out until the final step of the stepwise regression, all coefficients of the independent variables were not statistically significant at the 0.05 alpha level. However, most of the signs were as expected (See Table 7). The only exception was that of the ratio of imports to exports of general cargo (RITE) which entered the equation with a negative coefficient in 1974. This reversal of the expected sign further supports the premise that the system in 1974 was experiencing an infant growth stage because a balanced flow was not yet required to maintain continued growth.

Regression Analyses South Atlantic, 1974

Following the strategy prescribed earlier in this chapter, regression analyses were next performed on the data which were disaggregated into two subregions. The function of this procedure was to ascertain whether major differences, endemic to each subregion, were prevalent. If indeed regional differences in trading partners and flows existed, then hopefully higher levels of explanation could be achieved by disaggregation.

The results for the 145 observations in the South Atlantic region for 1974 were

$$\log NCTNX = \underset{(15.51)}{-0.37 \log DST} + \underset{(6.77)}{0.25 \log TCM}$$

$$R = 0.32 \quad \bar{R}^2 = 0.09 \quad F = 7.92$$

TABLE 7

SIGNS OF COEFFICIENTS FOR ESTIMATING EQUATIONS
SOUTH ATLANTIC-GULF COAST REGION, 1974 AND 1976

	1974		1976	
	NCTNX	NTNSX	NCTNX	NTNSX
DST	-*	-*	-*	-*
TCM	+	+*	+	+
RITE	-	-	+	+*
GNP	+	+	+*	+*
EGY	+	+	+	+*
CVH	-	-	-*	-*

Source: Author's individual regression analyses.

Note: Asterisk indicates coefficient is statistically significant at the 0.05 alpha level (two-tailed).

and

$$\log NTNSX = \underset{(19.61)}{-0.41 \log DST} + \underset{(11.53)}{0.32 \log TCM}$$

$R = 0.36 \quad \bar{R}^2 = 0.12 \quad F = 10.53$

The 1974 regression equations for the South Atlantic range explained nearly the same amount of variance as did the equations for the entire domestic region ($\bar{R}^2$ of 0.09 and 0.12 respectively). In addition, the same two variables, nautical distance and total commerce in general cargo, entered at statistically significant levels. Nautical distance, which had a higher F-ratio, was clearly the most important explanatory variable.

Extreme under-prediction, indicated by residuals greater than or equal to 1.5, occurred for major trading centers including Rotterdam, Tokyo, Melbourne, and Bremerhaven, which all also functioned as entrepots along with the ports of Hong Kong and Kobe. The Port of Greenock was an exception to the previously mentioned rule; it experienced under-prediction due to the return of containers for the eventual outbound shipment of spirits. For the most part, ports in developing economies experienced over-prediction with residuals less than or equal to -1.5. Typical ports in this category were Manta, Valencia, Paranagua, and Santo Domingo. In addition, relatively new ports, e.g., Fos sur Mer, in France, and some of the older established ports, such as Hamburg and Adelaide, also showed high negative residuals. Once again, the model performed poorly with regard to both large container ports and also for ports handling either large amounts of bulk cargoes or small ports in developing economies.

Regression Analyses South Atlantic, 1976

The estimating equations for the 226 observations for 1976 were

$$\log NCTNX = \underset{(25.98)}{-0.35 \log DST} + \underset{(30.72)}{0.38 \log TCM}$$

$R = 0.32 \quad \overline{R}^2 = 0.15 \quad F = 19.75$

and

$$\log NTNSX = \underset{(26.94)}{-0.35 \log DST} + \underset{(36.22)}{0.41 \log TCM}$$

$R = 0.41 \quad \overline{R}^2 = 0.16 \quad F = 22.12$

The same two variables, nautical distance and total volume of general cargo, entered the equation at statistically significant levels. However, in both equations total commerce replaced distance as the primary explanatory variables with F-ratios of 30.72 and 36.22 respectively. Although the model performed better for this later year, explained variance was still relatively low for both number of containers ($\overline{R}^2 = 0.15$) and number of tons ($\overline{R}^2 = 0.16$).

An examination of the residuals revealed that under-prediction, indicated by residuals greater than or equal to 1.5, fell into two categories. The first was major world ports which also functioned as transit facilities, i.e., Rotterdam, Hong Kong, and Bremerhaven. The second category was an anomaly and consisted of developing nation's ports that received larger than expected amounts of traffic due to the construction of a container facility such as Manta, in Ecuador, and Damman, in Saudi Arabia. Over-prediction of the extreme type was evident in older established terminals such as Antwerp, London, and Bremen. Apparently, by 1976 the development of major container

facilities was capturing general cargo which usually flowed through conventional ports.

A Comparison of the South Atlantic Region, 1974 and 1976

A comparison of the regression equations over the three year time period showed that in the latter year the model became more robust since explanation increased slightly. Nevertheless, the level of explanation left much to be desired.

It was interesting to note that the same two variables (DST and TCM) added to explanation at statistically significant levels in both years of the study. In addition, these same two variables were the only independent variables which also had statistical significance in the equations for the entire South Atlantic-Gulf coast region in 1974. The above point substantiated that in 1974 the world container system was in a developmental stage since the same variables were consistent in both regional models. In fact, commerce originating in the ports of the South Atlantic range seemed to contribute most toward explanation. However, by 1976 because of changes in explanatory variables for the larger domestic region, it can be deduced that sytematic changes were occurring.

Estimating equations, which included all six independent variables, were created for the South Atlantic range. All coefficients were not statistically significant at the 0.05 alpha level (See Table 8). The dependent variables (NCTNX and NTNSX) always were inversely related to nautical distance at significant levels. Total commerce in maritime general cargo remained positively related to containerized movements, but it was not significant for number of

TABLE 8

SIGNS OF COEFFICIENTS FOR ESTIMATING EQUATIONS
SOUTH ATLANTIC RANGE, 1974 AND 1976

	1974		1976	
	NCTNX	NTASX	NCTNX	NTNSA
DST	-*	-*	-*	-*
TCM	+	+*	+*	+*
RITE	-	-	-	-
GNP	-	-	+	+
EGY	+	-	+	+
CVH	+	+	-	-

Source: Author's individual regression analyses.

Note: Asterisks indicate coefficient is statistically significant at the 0.05 alpha level (two-tailed).

containers in 1974. The balanced flow variable (RITE) was negatively associated in all regressions supporting the absence of the two-way traffic requirement. In most cases, deficiencies either in inbound or outbound container cargoes could be potentially balanced by domestic or foreign coastwise movements. The sign of Gross National Product was inverse in the earlier year and positive in the latter. This shift stated that in the first year of the study economic affluence was not important in determining containerized flows; however, in the latter year it was. The sign of the coefficient for energy consumption per capita being positive reflected the importance of the industrialized economies in generating or receiving containerized cargoes. The negative sign in the formula for number of tons exported in 1974 was only slightly negative and could have been an anomaly. Finally, the number of commercial vehicles changed from positive to negative during the study period indicating a mature land transport system (other than trucking) or the development of short sea shipping and/or feeder services at foreign destinations.

Regression Analyses Gulf, 1974

The estimating equations for the 190 observations in 1974 were

$$\log NCTNX = \underset{(23.87)}{0.34 \log GNP}$$

$$R = 0.34 \quad \bar{R}^2 = 0.16 \quad F = 12.24$$

and

$$\log NTNSX = \underset{(5.08)}{0.31 \log TMC} + \underset{(5.98)}{0.45 \log GNP} - \underset{(4.80)}{0.39 \log CVH}$$

$$R = 0.41 \quad \bar{R}^2 = 0.16 \quad F = 12.24$$

Gross National Product was the only variable to enter the estimating equation for number of containers exported (NCTNX) at a statistically significant level and it explained eleven percent of the variance. Three dependent variables, total commerce, Gross National Product, and commercial vehicles were statistically significant and explained sixteen percent of the variance in containerized tonnage (NTNSX). In the second equation, GNP clearly contributed most toward explanation, followed by total commerce and commercial vehicles. A better performance of the model in the latter situation for the first time in the study, both with regard to explanation and supporting variables, indicated that tonnage was probably a better indicator of flows than was absolute numbers of containers. Number of containers does not account for variations in the physical size of boxes--20 feet to 60 feet in length, while tonnage incorporates such varying dimensions.

In order to obtain additional information with regard to model performance, residuals were examined noting their geographic orientation. Under-prediction, indicated by residuals greater than or equal to 1.5, appeared for three groups of countries. The first group was international load centers, i.e., Rotterdam, Bremerhaven, and Hong Kong. The second consisted of the two major Australian ports, Sydney and Melbourne, which both act as national load centers. Ports in developing economies which had constructed container facilities, i.e., Santos, Tuxpan, and the port area on the island of Aruba form the third group. Over-prediction resulted for older ports such as Liverpool, Manchester, and Genoa and small ports in developing nations such as Fortaleza, in Brazil.

Regression Analyses Gulf, 1976

Two hundred sixty-two observations contributed to the following estimating equations for 1976:

$$\log NCTNX = \underset{(7.21)}{0.16 \log EGY}$$

$$R = 0.16 \quad \bar{R}^2 = 0.03 \quad F = 7.21$$

and

$$\log NTNSX = \underset{(5.89)}{0.28 \log GNP} + \underset{(9.61)}{0.22 \log EGY} - \underset{(7.71)}{0.32 \log CVH}$$

$$R = 0.27 \quad \bar{R}^2 = 0.06 \quad F = 6.30$$

Only one variable (EGY) entered the first equation at a statistically significant level, while three variables (GNP, EGY, and CVH) were significant in the second equation. In the absolute number of containers equation, energy consumption per capita explained only a meager amount of variance. However, it was the first instance that energy consumption alone contributed to explanation. In all probability, close economic ties between Persian Gulf nations and the U.S. Gulf region resulting from oil industry interests encouraged movements of containers between the two areas. In addition, foreign oil monies have led to sizable inbound movements of manufactured and consumer items. Although explanation was somewhat better in the latter equation, it still left much to be desired. Energy consumption per capita clearly was the greatest contributor to explanation followed by commercial vehicles and gross national product. The signs of the coefficients of all three variables were consistent with what would be expected for Middle Eastern oil producing economies.

By examining the geographic distribution of very high or very low residuals, a better understanding of weaknesses in the model became possible. Severe under-prediction was evident for international load centers including Rotterdam and Bremerhaven. In addition, over-prediction resulted for the modern developing nation's ports of Puerto Cortez, Santos, and Rio De Janeiro as well as the ports of Melbourne and Sydney, in Australia, and the twin ports of Lagos and Apapa, in Nigeria. Over-prediction, once again, typified ports in older developed economies such as Stockholm, Dublin, Naples and Capetown. Thus, the model does not perform well for flows which are either very large or very small.

A Comparison of the Gulf Region, 1974 and 1976

Unlike the regression equations for the South Atlantic region over the three year period, equations for the Gulf region became less robust since explanation decreased. In fact, explanation reached its lowest point compared to all previous models.

The period for the Gulf range was one of transition. In the earlier equations, Gross National Product was the major explanatory variable, while in the latter year a shift took place and energy consumption per capita became most important. This shift apparently was caused by increased containerized exports to Persian Gulf Oil producing nations.

In the same manner as previous sections, a final examination of the signs of the coefficients of the six variable model was conducted. Table 9 reveals the signs which were statistically significant marked with an asterisk. Distance, as expected was inversely related to both

TABLE 9

SIGNS OF COEFFICIENTS FOR ESTIMATING EQUATIONS
GULF RANGE, 1974 AND 1976

	1974		1976	
	NCTNX	NTNSX	NCTNX	NTNSX
DST	-	-	-	-
TCM	+	+*	-	-
RITE	+	+	+	+
GNP	+*	+*	+*	+*
EGY	+	+	+*	+*
CVH	-*	-*	-*	-*

Source: Author's individual regression analyses.

Note: Asterisks indicate coefficient is statistically significant at the 0.05 alpha level (two-tailed).

number and volume of containers shipped, but was not significant. A change in the sign of total commerce in general cargo from positive to negative reinforces the idea that exports to oil producing countries was increasing although international trade was growing at a declining rate. However, the positive sign of the ratio of imports to exports on the other hand supports the balanced trade argument. Gross National Product was statistically significant in all equations indicating that containerized trade occurred primarily among well-developed economies and also oil producing economies. Energy consumption per capita being positive supports the premise of container trade dominance by industrialized and oil producing nations. Finally, the negative sign of the commercial vehicle variable, which was significant in all equations, once again indicated the complexities of achieving door-to-door movements world-wide.

Gravity/Regression Analyses Aggregated on Foreign Countries

Introduction

Further analyses performed on the domestic state level did not greatly improve explanation; therefore, their results have not been reported. Because of the overall poor results to explain variance, a reevaluation of the previous methods was undertaken. Apparently, numerous dyads or small absolute size of the dependent variable were hindering the model's ability to achieve higher orders of explanation. To remedy this situation, data were aggregated on the basis of domestic port traffic to foreign countries. Thus, the original methodology of preserving point-to-point or port-to-port containerized movements was abandoned. This change necessitated not only summing the data

involving shipments from domestic ports to various foreign ports but also recomputing the distance variable. Distance was recalculated by observing the largest flow between a domestic port and its largest counterpart in a specific foreign country, and then assigning that distance to the toal flow between domestic origin and foreign country.

The rationale for the prior mentioned methodology focused on an attempt to be more port specific than former studies by Schultz and Marti (1980) and Yeates (1969). However, the integrity of providing an analysis in keeping with the original objective was partially conserved

by aggregating the data only with respect to foreign national destination. The following regressions involve a much smaller data set. In addition, because their coefficients of determination for the most part indicated better fits, the usual assumptions of regression analysis were addressed for subsequent selections only.

Number of Containers South Atlantic-Gulf Coast, 1974

The domestic port/foreign country gravity model's results for 1974 were found as follows:

$$\log NCTNX = -4.27 - \underset{(0.1990)}{0.88}\log DST + \underset{(0.0982)}{0.69}\log TCM$$

$$\bar{R}^2 = 0.2155 \quad F = 27.78 \quad S = 2.1358 \quad n = 196$$

where $\bar{R}^2$ is the coefficient of determination adjusted for degrees of freedom, F is the ratio of mean square explained to mean square unexplained, S is the standard error of estimate, and n is the number of observations. Standard errors are in parentheses below the estimated coefficients.

The equation fits the data far better that the equation which included port-to-port movements, as indicated by an $\overline{R}^2$ which almost doubled. The same two independent variables, DST and TCM, contributed to explanation at statistically significant levels as in the prior disaggregated equation. Therefore, one can safely state that with the exception of increased explanation, very little change resulted from aggregating the data.

The Pearson correlation coefficient for the two independent variables entering the equation was 0.38043 with a significance of 0.0001. Therefore, the presence of multicollinearity was not severe. Testing for spatial autocorrelation is a complex task. Autocorrelation generally is of interest to the geographer when attempting to define new explanatory variables. In fact, it is believed that sizeable amounts of autocorrelation exist among the data given their nature. The container data account for actual port to country flows, but do not guarantee that the ultimate destination of container flows is within the same country of entry. For instance, large amounts of the container movements to the Port of Rotterdam eventually move to nations other than the Netherlands either by overland transport or marine transport. Thus, the concept of a load center does not necessarily only apply to domestic final destinations. Ports, such as Rotterdam, which handle large amounts of cargo to be transshipped to other foreign ports are sometimes known as "pivot ports."

A test for assessing whether heteroscedasticity exists was first suggested by Goldfeld and Quandt (1965) and was applied to gravity models by Stronge and Schultz (1978). In the same manner, similar

tests were applied to the results of the gravity/regression model in this study. The usual procedure involves grouping the data by an independent variable and then performing separate regression analyses on both the lower and upper groups of observations. The residual mean squares from the two regressions are estimates of the disturbance variances, and the test is based upon the ratio of the two mean squares. The null hypothesis is that the two disturbance variances are the same. If the computed F exceeds the tabulated F, heteroscedasticity is said to exist and must be corrected for with a transformation. Following the above procedure, the equation for 1974, as well as all remaining equations, was tested for heteroscedasticity.

After grouping the data on the mass variable (TCM), ten central observations were omitted and the regression was run on the two equally sized samples. The results were

lower sample: $\log NCTNX = 7.65 - \underset{(0.1990)}{0.87}\log DST + \underset{(0.0982)}{0.29}\log TCM$

$\bar{R}^2 = 0.1268 \quad F = 7.68 \quad S = 2.0356 \quad n = 93;$

upper sample: $\log NCTNX = -8.12 - \underset{(0.5158)}{0.37}\log DST + \underset{(0.3471)}{1.40}\log TCM$

$\bar{R}^2 = 0.1341 \quad F = 8.12 \quad S = 2.2734 \quad n = 93.$

The residual sum of squares from the lower sample, $(n-3)S_1^2$, was 372.9173 and the residual sum of squares from the upper sample, $(n-3)S_2^2$, was 448.6017 so that the computed F was $S_2^2/S_1^2 = 1.2030$ which was less than the table F of 1.4000. Therefore, heteroscedasticity was not evident due to the total commerce variable.

To assess whether the distance variable contributed to heteroscedasticity, a similar test was run after sorting the data on the logarithm of the variable DST and omitting the ten central observations. The results were

lower sample: $\log NCTNX = 5.71 - \underset{(0.4900)}{0.98}\log DST + \underset{(0.2029)}{0.62}\log TCM$

$\overline{R}^2 = 0.0765 \quad F = 4.81 \quad S = 2.3212 \quad n = 93;$

upper sample: $\log NTNSX = -4.02 - \underset{(0.6547)}{0.41}\log DST + \underset{(0.1247)}{0.76}\log TCM$

$\overline{R}^2 = 0.2806 \quad F = 18.94 \quad S = 1.8443 \quad n = 93.$

The residual sum of squares from the lower sample, $(n-3)S_1^2$, was 484.9066 and the residual sum of squares from the upper sample, $(n-3)S_2^2$, was 306.1360 so that the computed F was $S_1^2/S_2^2 = 1.5840$. Since the computed F exceeded the tabulated F, a transformation was needed to correct for heteroscedasticity.

Thus, the regression equation, with adjustment for heteroscedasticity becomes

$\log DST \log NCTNX = \underset{(0.1264)}{14.29}\log DST - \underset{(0.0948)}{0.65}\log^2 DST + 0.75 \log DST \log TCM$

$\overline{R}^2 = 0.2382 \quad F = 31.48 \quad S = 17.6472 \quad n = 196.$

With the logarithmic transformation the adjusted coefficient of determination increased by slightly over two percent and the standard errors of estimate decreased indicating a better fit.

In a similar manner, the data were sorted on the log of DST and divided into two equal groups omitting ten central observations. The results of the regressions were

lower sample:

$$\text{logDSTlogNCTNX} = 23.23\text{logDST} - \underset{(0.1264)}{0.65\log^2\text{DST}} + \underset{(0.0948)}{0.75\text{logDSTlogTCM}}$$

$$\bar{R}^2 = 0.1576 \quad F = 9.61 \quad S = 17.8713 \quad n = 93;$$

upper sample:

$$\text{logDSTlogNCTNX} = -17.45\text{logDST} - \underset{(0.3302)}{0.28\log^2\text{DST}} + \underset{(0.1244)}{0.77\text{logDSTlogTCM}}$$

$$\bar{R}^2 = 0.2856 \quad F = 19.39 \quad S = 16.6810 \quad n = 93.$$

The residual sum of squares from the lower sample, $(n-3)S_1^2$, was 28744.8034 and the residual sum of squares from the upper sample, $(n-3)S_2^2$, was 25042.1360 so that the computed F was $S_1^2/S_2^2 = 1.1487$. The computed F was less than the tabulated F, therefore, heteroscedasticity attributed to distance has been corrected for. Thus, corrections for heteroscedasticity added an additional two percent toward explanation.

Number of Tons South Atlantic-Gulf Coast, 1974

The results of the domestic port/foreign country gravity model for 1974 were found as follows:

$$\text{logNTNSX} = 6.25 - \underset{(0.2142)}{0.95\text{logDST}} + \underset{(0.1057)}{0.80\text{logTCM}}$$

$$\bar{R}^2 = 0.2340 \quad F = 30.79 \quad S = 2.2987 \quad n = 196.$$

Once again, even after aggregating the data, the same two dependent variables (TCM and DST) entered the equation at statistically significant levels. Adjusted R-square also increased by over eleven percent. Multicollinearity was minimal since the Pearson correlation coefficient for the two variables entering the equation was relatively low at 0.38043 with a significance of 0.0001. Autocorrelation in the above

equation as well as in all further equations was apparently present for reasons previously mentioned.

When assessing for heteroscedasticity caused by the mass variable (TCM), the results for the two groups sorted by the log of the mass variable, leaving out the ten central observations were as follows:

lower sample: $\log NTNSX = 10.66 - \underset{(0.2490)}{0.84}\log DST + \underset{(0.2409)}{0.17}\log TCM$

$\bar{R}^2 = 0.0982 \quad F = 6.01 \quad S = 2.2734 \quad n = 93;$

upper sample: $\log NTNSX = -4.67 - \underset{(0.5158)}{0.55}\log DST + \underset{(0.3474)}{0.17}\log TCM$

$\bar{R}^2 = 0.1389 \quad F = 8.42 \quad S = 2.2919 \quad n = 93.$

The residual sum of squares from the lower sample, $(n-3)S_1^2$, was 465.1711 and the residual sum of squares from the upper sample, $(n-3)S_2^2$, was 472.7457 resulting in computed F, $(S_2^2/S_1^2$ = of 1.0163. The computed F was less than the F-table of 1.400; therefore, heteroscedasticity was not caused by the total commerce variable.

Testing in the same manner after sorting on logDST, the following results occurred:

lower sample: $\log NTNSX = -4.02 - \underset{(0.5252)}{0.04}\log DST + \underset{(0.2175)}{0.76}\log TCM$

$\bar{R}^2 = 0.0758 \quad F = 4.78 \quad S = 2.4882 \quad n = 93;$

upper sample: $\log NTNSX = -1.11 - \underset{(0.7057)}{0.24}\log DST + \underset{(0.1344)}{0.89}\log TCM$

$\bar{R}^2 = 0.3148 \quad F = 22.13 \quad S = 1.9879 \quad n = 93.$

The residual sum of squares from the lower sample, $(n-3)S_1^2$, was 557.1876 and the residual sum of squares from the upper sample, $(n-3)S_2^2$, was 355.6678. The computed F, (S_1^2/S_2^2) was 1.5666 and exceeded

the F-table of 1.4000. Therefore, a transformation was needed to correct for heteroscedasticity caused by the distance variable.

After multiplying the quantities on both sides of the equation by logDST, the results for the regression equation became

$$\text{logDSTlogNTNSX} = 22.31\text{logDST} - \underset{(0.1355)}{0.61\log^2\text{DST}} + \underset{(0.1016)}{0.87}\text{logDSTlogTCM}$$

$$\bar{R}^2 = 0.2645 \quad F = 49.79 \quad S = 18.9122 \quad n = 196.$$

As a result of the transformation, the $\bar{R}^2$ increased slightly and the appropriate standard errors of estimate decreased indicating a better overall fit.

A check for the presence of heteroscedasticity resulted in the following regression equations

lower sample:

$$\text{logDSTlogNTNSX} = -29.46\text{logDST} - \underset{(0.3893)}{0.72\log^2\text{DST}} + \underset{(0.2227)}{0.86}\text{logDSTlogTCM}$$

$$\bar{R}^2 = 0.2097 \quad F = 13.21 \quad S = 19.0473 \quad n = 93;$$

upper sample:

$$\text{logDSTlogNTNSX} = 17.45\text{logDST} - \underset{(0.3302)}{0.22\log^2\text{DST}} + \underset{(0.1944)}{0.77}\text{logDSTlogTCM}$$

$$\bar{R}^2 = 0.2556 \quad F = 19.39 \quad S = 17.9555 \quad n = 93.$$

The residual sum of squares from the lower sample, $(n-3)S_1^2$, was 32652.0324 and the residual sum of squares from the upper sample, $(n-3)S_2^2$, was 29016.1032. The computed F of 1.1253 was less than the tabulated F of 1.4000, therefore, the heteroscedasticity attributable from the influence of the distance variable was corrected for.

Number of Containers South Atlantic-Gulf Coast, 1976

The regression results for containers, when the data were collapsed to include foreign importing countries, were found as follows.

$$\log NCTNX = 3.47 - 0.98\log DST + 0.29\log TCM + 0.50\log GNP - 0.36\log CVH$$
$$(0.1916) \quad (0.1500) \quad (0.1611) \quad (0.1561)$$

$$\bar{R}^2 = 0.1538 \quad F = 14.59 \quad S = 2.2069 \quad n = 300.$$

A moderate increase in explanation was accomplished by aggregating the data to the foreign country level. Four independent variables entered the equation at statistically significant levels less than or equal to 0.05 alpha. The two highest F-values for the coefficients were 26.16 for the distance variable and 9.56 for the gross national product variable.

Pearson correlation coefficients for the variables entering the equation are recorded below:

	logDST	logTCM	logGNP	logCVH
logDST	1.00000 0.0000	0.16389 0.0044	0.16014 0.0054	0.13595 0.0185
logTCM	0.16389 0.0044	1.00000 0.0000	0.84041 0.0001	0.80175 0.0001
logGNP	0.16014 0.0054	0.84041 0.0001	1.00000 0.0000	0.86217 0.0001
logCVH	0.13595 0.0185	0.80175 0.0001	0.86217 0.0001	1.00000 0.0000

The upper number is the correlation coefficient, while the lowest is the significance. It should be noted that the three mass variables are moderately highly correlated with each other. Thus, the presence of multicollinearity among the three variables is suspected. However, the usual procedure of either dropping variables which are highly

correlated or finding new variables was not practiced in this study since the major objective was to test whether variables cited in the literature could explain variance in the container flows. As stated in earlier paragraphs, spatial correlation was probably evident due to the nature of the data.

Tests were run to ascertain whether heteroscedasticity was caused by the two independent variables having the highest F-values. In practice, all of the heteroscedasticity could be removed by continuously utilizing statistical transformations. However, the scope of this paper allowed for maximum of testing for heteroscedasticity in only the two dependent variables contributing the most toward explanation. Sorting on the logarithm of distance and leaving out twenty central observations, the results for the domestic port/foreign country model for 1976 were

lower sample:

$$\underset{}{\log NCTNX} = \underset{}{0.12} - \underset{(0.4680)}{0.88}\log DST + \underset{(0.2416)}{0.49}\log TCM + \underset{(0.2415)}{0.50}\log GNP - \underset{(0.2635)}{0.37}\log CVH$$

$$\bar{R}^2 = 0.0932 \quad F = 4.57 \quad S = 2.3538 \quad n = 140;$$

upper sample:

$$\underset{}{\log NCTNX} = \underset{}{3.33} - \underset{(0.6876)}{0.76}\log DST - \underset{(0.2185)}{0.08}\log TCM + \underset{(0.2481)}{0.56}\log GNP - \underset{(0.2085)}{0.16}\log CVH$$

$$\bar{R}^2 = 0.0801 \quad F = 4.03 \quad S = 2.0501 \quad n = 140.$$

The residual sum of squares from the lower sample, $(n-5)S_1^2$, was 747.4390 and the residual sum of squares from the upper sample, $(n-5)S_2^2$, was 567.3707 resulting in a computed F (S_1^2/S_2^2) of 1.3174.

The computed F was slightly less than the F-table of 1.3305 indicating that heteroscedasticity resulting from the distance variable was not a problem.

The test for the same regression sorted on the logarithm of GNP gave the following results

lower sample:

$$\text{logNCTNX} = 8.92 - \underset{(0.2081)}{0.88}\text{logDST} + \underset{(0.1833)}{0.06}\text{logTCM} + \underset{(0.2217)}{0.51}\text{logGNP} - \underset{(0.1918)}{0.17}\text{logCVH}$$

$$\bar{R}^2 = 0.1101 \quad F = 5.30 \quad S = 1.8891 \quad n = 140;$$

upper sample:

$$\text{logNCTNX} = -11.17 - \underset{(0.4425)}{0.27}\text{logDST} - \underset{(0.2574)}{0.44}\text{logTCM} + \underset{(0.3223)}{1.10}\text{logGNP} - \underset{(0.2506)}{0.56}\text{logCVH}$$

$$\bar{R}^2 = 0.1224 \quad F = 5.85 \quad S = 2.4735 \quad n = 140.$$

The residual sum of squares from the lower sample, $(n-5)S_1^2$, was 481.7743 and the residual sum of squares from the upper sample, $(n-5)S_2^2$, was 825.9978. Since the computed F of 1.7144 (S_2^2/S_1^2) exceeded the F-table of 1.3305 a transformation was needed to correct for heteroscedasticity caused by the variable logGNP.

The appropriate transformation was to multiply both sides of the regression equation by the reciprocal of the log of GNP. The resulting equation yielded

$$\text{logNCTNX/logGNP} = \underset{}{0.36}/\text{logGNP} - \underset{(0.1708)}{1.10}\text{logDST/logGNP} + \underset{(0.1401)}{0.24}\text{logTCM/logGNP}$$

$$+ \underset{(2.0714)}{6.35}\text{logGNP/logGNP} - \underset{(0.1374)}{0.34}\text{logCVH/logGNP}$$

$$\bar{R}^2 = 0.1724 \quad F = 16.57 \quad S = 0.2247 \quad n = 300.$$

With the reciprocal, $\overline{R}^2$ increased slightly and all standard errors of estimate decreased.

Grouping on the log of GNP and omitting twenty central observations yielded the following two regression equations necessary to assess whether heteroscedasticity had been corrected for

lower sample:

$$\log NCNTX/\log GNP = -0.01/\log GNP - 0.99 \log DST/\log GNP + 0.06 \log TCM/\log GNP$$
$$(0.2045) \qquad (0.1768)$$
$$+ 10.61 \log GNP/\log GNP - 0.08 \log CVH/\log GNP$$
$$(2.5917) \qquad (0.1738)$$

$$\overline{R}^2 = 0.3057 \quad F = 16.30 \quad S = 0.2301 \quad n = 140;$$

upper sample:

$$\log NCNTX/\log GNP = -1.07/\log GNP - 0.32 \log DST/\log GNP + 0.47 \log TCM/\log GNP$$
$$(0.4296) \qquad (0.2548)$$
$$+ 10.65 \log GNP/\log GNP - 0.56 \log CVH/\log GNP$$
$$(5.9436) \qquad (0.2520)$$

$$\overline{R}^2 = 0.0611 \quad F = 3.22 \quad S = 0.2156 \quad n = 140.$$

The residual sum of squares from the lower sample, $(n-5)S_1^2$, was 7.1473 and the residual sum of squares from the upper sample, $(n-5)S_2^2$, was 5.4680. The computed F of 1.1051 was less than the tabulated F of 1.3305, so apparently heteroscedasticity attributed to the gross national product variable had been corrected for.

Number of Tons South Atlantic-Gulf Coast, 1976

Data collapsed to the foreign country level for the year 1976 yielded the following regression equation:

$$\log NTNSX = 8.24 - 0.89 \log DST + 0.36 \log GNP + 0.26 \log EGY$$
$$(0.2147) \qquad (0.0938) \qquad (0.1157)$$

$$\overline{R}^2 = 0.1445 \quad F = 18.22 \quad S = 2.4229 \quad n = 300$$

and increased the adjusted R-square with respect to the prior model of port-to-port movements. Among the three independent variables the highest F-value was for the coefficient of DST (17.27) followed by the coefficient of GNP (14.37).

The Pearson correlation coefficients for the significant variables were

	logDST	logGNP	logEGY
logDST	1.00000 0.0000	0.16014 0.0054	-0.09249 0.1099
logGNP	0.16014 0.0054	1.00000 0.0000	0.51739 0.0001
logEGY	-0.09249 0.1099	0.51739 0.0001	1.00000 0.0000

The mass variables for gross national product and energy consumption were moderately highly correlated and, therefore, presented bias problems associated with multicollinearity. Nevertheless, they were not dropped from the analysis due to prior reasoning.

Tests for heteroscedasticity yielded the following two equations when sorted on the log of distance

lower sample:

$$\underset{}{\log NTNSX} = \underset{}{6.18} - \underset{(0.4774)}{0.67}\log DST + \underset{(0.1431)}{0.22}\log GNP + \underset{(0.2237)}{0.50}\log EGY$$

$$\bar{R}^2 = 0.0899 \quad F = 5.57 \quad S = 2.5467 \quad n = 140;$$

upper sample:

$$\underset{}{\log NTNSX} = \underset{}{4.74} - \underset{(0.7045)}{0.54}\log DST + \underset{(0.1561)}{0.48}\log GNP + \underset{(0.1374)}{0.12}\log EGY$$

$$\bar{R}^2 = 0.0794 \quad F = 5.00 \quad S = 2.3147 \quad n = 140.$$

The residual sum of squares from the lower sample, $(n-4)S_1^2$, was

882.0209 and the residual sum of squares from the upper sample, $(n-4)S_2^2$, was 728.6809. The computed F of 1.2104 was less than the tabulated F of 1.3300; therefore, heteroscedasticity was not a problem with regard to the distance variable.

The same procedure was accomplished after sorting on the log of GNP. The results of the regression equations were

lower sample:

$$\log NTNSX = -12.34 - \underset{(0.2307)}{0.89}\log DST - \underset{(0.1515)}{0.10}\log GNP + \underset{(0.1240)}{0.20}\log EGY$$

$$\bar{R}^2 = 0.1172 \quad F = 7.16 \quad S = 2.1068 \quad n = 140;$$

upper sample:

$$\log NTNSX = -3.57 - \underset{(0.5059)}{0.18}\log DST + \underset{(0.2870)}{0.85}\log GNP + \underset{(0.2773)}{0.27}\log EGY$$

$$\bar{R}^2 = 0.0980 \quad F = 6.08 \quad S = 2.7181 \quad n = 140.$$

The residual sum of squares from the lower sample, $(n-4)S_1^2$, was 603.6325 and the residual sum of squares from the upper sample, $(n-4)S_2^2$, was 1004.7041. This yielded a computed F of 1.6645 which exceeded the table F of 1.3300. Therefore, it became necessary to multiply both sides of the sides of the equation by the reciprocal of logGNP to adjust for heteroscedasticity. The estimating equation then became

$$\log NTNSX/\log GNP = -\underset{}{0.20}/\log GNP - \underset{(0.1741)}{1.03}\log DST/\log GNP +$$

$$\underset{(1.4959)}{9.21}\log GNP/\log GNP + \underset{(0.0899)}{0.16}\log EGY/\log GNP$$

$$\bar{R}^2 = 0.1652 \quad F = 20.73 \quad S = 0.2256 \quad n = 300.$$

Again, adjusted R-square increased slightly when adjustments were made for heteroscedasticity.

The results for the regressions for the upper and lower samples were

lower sample:

$$\log NTNSX/\log GNP = -0.05/\log GNP - 0.96\log DST/\log GNP + 11.07\log GNP/\log GNP$$
$$(0.2031) \qquad (1.7576)$$
$$+ 0.07\log EGY/\log GNP$$
$$(0.1090)$$

$$\bar{R}^2 = 0.3115 \quad F = 21.97 \quad S = 0.2291 \quad n = 140;$$

upper sample:

$$\log NTNSX/\log GNP = -0.75/\log GNP - 0.13\log DST/\log GNP - 4.85\log GNP/\log GNP$$
$$(0.4500) \qquad (5.4147)$$
$$+ 0.25\log EGY/\log GNP$$
$$(0.2076)$$

$$\bar{R}^2 = 0.0321 \quad F = 2.54 \quad S = 0.2188 \quad n = 140.$$

The residual sum of squares from the lower sample, $(n-4)S_1^2$, was 7.1399 and the residual sum of squares from the upper sample, $(n-4)S_2^2$, was 6.5105. The computed F of 1.0967 was less than the F-table of 1.3300; heteroscedasticity from the Gross National Product variable had statistically been accounted for.

Other Regressions of Containers and Tonnage, 1974

Numerous other attempts were made to obtain better fits of the model by constraining the dependent variables. Observations of either the very low or very high absolute values were apparently still contributing to the generally poor explanatory power of the model. First, values less than or equal to 50 containers along with flows to the Netherlands (Country 630) were omitted from the South Atlantic-Gulf

model. Next, in addition to the Netherlands, Country 394 (West Germany) was also omitted; and finally, Country 490 (Japan) was also omitted.

The results for the constrained models for the South Atlantic-Gulf Coast were recorded in Appendix E where R is the multiple correlation coefficient, $\overline{R}^2$ is the coefficient of determination adjusted for degrees of freedom, and F is the ratio of mean square explained to mean square unexplained. F-ratios are written in parentheses below the coefficients. The regressions did not provide better fits, therefore, they were not covered extensively in the text of this work.

Of all the remaining models for 1974, those run on individual domestic ports to foreign countries provided the greatest explanatory power. The actual equations may be seen in table form in Appendix F, along with the statistical testing for heteroscedasticity. Due to the relatively small n (number of case) when the data were disaggregated on the domestic port level, the only ports included were Charleston, South Carolina; Miami, Florida; New Orleans, Louisiana; and Savannah, Georgia. These are among the major ports in the South Atlantic-Gulf Coast region and as such provided the largest amounts of containerized exports to foreign countries. Data for Houston, Texas, were not included in this section since it was not possible to correct for heteroscedasticity utilizing simple transformations.

The 1974 Charleston port-to-country container model accounted for a respectable amount of explanation ($\overline{R}^2 = 0.6135$). Total commerce in maritime general cargo was the only variable able to explain flows of

containers at a statistically significant level from this South Carolina port. Export movements involved 24 different foreign countries. After sorting on the logarithm of the independent mass variable (TCM) and omitting four central observations, regression analyses were performed on both the low and upper samples. The resulting Goldfeld-Quandt test indicated that heteroscedasticity attributed to the mass variable was not present. When the model was applied to container tonnage originating at the Port of Charleston during 1974, once again, only total commerce in maritime general cargo contributed to explanation at a statistically significant level. The coefficient of determination, adjusted for degrees of freedom, stood at 0.6028. Testing revealed that total commerce's contribution toward explanation of container tonnage variance did not violate the homoscedacity assumption of regression analysis.

The port-to-country regression analyses for the Port of Miami also included only one statistically significant independent variable--nautical distance. The model for number of containers explained 63.17 percent of the variance in flows, while that for containerized tonnage accounted for 56.83 of the flow variance. Although the sample size was relatively small (n equal to nineteen), similar tests, after omitting three central observations, were performed to ascertain whether heteroscedasticity was present. In the analysis for containers, heteroscedasticity was not a problem; however, the analysis for tonnage required a statistical transformation in order to satisfy the homoscedascity assumption. After multiplying all elements of the equation by the reciprocal of the logarithm of nautical distance,

heteroscedasticity was corrected for the coefficient of determination increased to 73.66 percent.

The regression analyses for the Port of New Orleans provided the lowest amounts of explanation with regard to the four ports observed ($\bar{R}^2$ = 0.3492 for containers and 0.3301 for tonnage). Tests for heteroscedasticity in both equations, which involved forty-six foreign country destinations, did not reveal that heteroscedasticity was present.

Savannah's port-to-country container model, involving twenty-one foreign nations, achieved an $\bar{R}^2$ of 0.4780 and included two independent variables at statistically significant levels--nautical distance and energy per capita consumption. Neither dependent variable caused heteroscedasticity. The same two variables were able to explain, at statistically significant levels, only 0.3983 of the variance in containerized tonnage. Heteroscedasticity resulted from the energy variable. After the appropriate transformation, the homoscedacity assumption was satisfied and the coefficient of determination increased to 0.6263.

All analyses, except for Savannah, involved single dependent variables. Total commerce in maritime general cargo was a significant factor adding to explanation in five of the eight equations. Nautical distance separating exporting and importing centers was the only controlling factor for Florida exports, while nautical distance traveled for containers and total commerce for tonnage along with per capita energy consumption influenced Savannah's exports.

Other Regression of Containers and Tonnage, 1976

Attempts were also made to constrain dependent variable in the 1975 regression equations. Following the previous methodology, the same constraints were accomplished leading to little to no improvement. Appendix G shows the results for the forementioned regressions.

The regression equation for the 1976 Charleston port-to-country container model had a coefficient of determination ($\overline{R^2}$) of 0.5283. Two variables--nautical distance and total maritime commerce in general cargo--contributed to explanation at a statistically significant level. Container movements originating at Charleston involved 33 different nations. When the Goldfeld-Quandt test was applied to measure if heteroscedasticity was present, the computed F was less than the tabulated F indicating that heteroscedasticity was not a problem. The equation for containerized tonnage, although it was able to explain more of the flow variance ($\overline{R^2}$ = 0.5375) utilizing the same two variables, had heteroscedasticity attributable to the total commerce variable. After statistically transforming the equation by multiplying all terms by the logarithm of total commerce, heteroscedasticity was corrected for the the $\overline{R^2}$ increased to 73.05.

Miami's 1976 port-to-country regression analyses, just as in the initial study year, involved a single dependent variable (DST). This port exported containers to 30 different foreign countries. The coefficients of determination were 27.46 percent for containers and 30.32 percent for tonnage. Test for heteroscedasticity revealed that the homoscedasticity assumption was satisfied in both equations.

Nautical distance and Gross National Product both contributed toward explanation of New Orlean's containerized export flows. However, explanation ($\overline{R}^2$ = 0.2076 for containers and $\overline{R}^2$ = 0.2056 for tonnage) was the lowest recorded for the four ports surveyed in this study. The sample size was relatively large and involved 52 foreign country destinations. Once again, heteroscedasticity was not a factor in the container model, but it was in the tonnage model. Correcting for heteroscedasticity caused by the mass variable (GNP) resulted in a decrease in explanation in the tonnage model to only 8.53 percent.

Savannah's 1976 port-to-country models, which included 43 foreign destinations involved two independent variables--nautical distance and Gross National Product. The container equation explained 52.25 percent of the flow variance, while the tonnage equation explained only 48.73 percent. Tests for heteroscedasticity in both equations were negative.

Only Miami, in the latter year's equations, had a single dependent variable equation. However, nautical distance was included at a statistically significant level in all regressions. Total maritime commerce, unlike in the earlier year of the study, was only important in describing exports from Charleston. Gross National Product in addition to distance contributed toward explanation in both the exports from New Orleans and Savannah. Coefficients of determination only increased, compared to those of 1974, for Charleston with regard to containers and for Savannah with regard to tonnage. Therefore, much like the earlier port-to-port regressions the degree of

explanation generally decreased from the principal year to the terminal year of the study, and further supports the premise that the container system was getting more complex through time.

Summary

The statistical analyses chapter applied a gravity/regression model toward the study of containerized cargo flows which originated at U.S. Atlantic-Gulf Coast ports. Regression analyses were performed for two years, 1974 and 1976, on two dependent variables--number of containers and number of tons. The function of the model was to test the validity of statements in the literature of containerization with regard to the contribution of six qualitative variables toward influencing and explaining the generation of maritime container movements.

A stepwise procedure was followed to ascertain whether the six variables indeed described the historical flow of containers. The procedure was carried out on four levels:

(1) on port-to-port movements beginning in the combined South-Atlantic Gulf Coast region;

(2) on port-to-port movements starting in the individual two domestic port ranges;

(3) on port-to-country movements for the entire South Atlantic-Gulf Coast region; and

(4) on port-to-country movements for four of the major ports contained within the domestic port ranges.

Within the text of this work, the seven critical assumptions of regression were addressed only for the port-to-country equations since

they provided the highest amount of explanation. Regression analyses for the port-to-port data showed that, first, total commerce in maritime general cargo and, second, nautical distance separating trading ports were the best variables adding to explanation of the variance of container flows for the entire region in 1974. By 1976, the situation became more complex with four of the possible six variables contributing to explanation at statistically significant levels. Therefore, one must assume that the container system became more complex.

In an attempt to increase explanation, the data were disaggregated into two regions, South Atlantic and Gulf, and regression analyses were performed on each region. In this manner, it was hoped that various subtle idiosyncrasies attributed to regional differences could be discovered. Within the South Atlantic region, distance and total commerce remained consistently the primary variables able to explain variances in container flows. However, the Gulf region apparently was undergoing a transition period. The estimating equations for absolute number of containers showed that only Gross National Product was able to add to explanation in 1974, while by 1976, the only explanatory variable was energy consumption per capita. On the other hand, estimating equations for containerized tonnage in addition to a shift to GNP as the most important variable in 1976 also included energy consumption and commercial vehicles. Thus, the model demonstrated that the U.S. Gulf's ports were in a state of flux, as different factors were influencing the development of that region's containerized exports.

After aggregation of the foreign ports to country level, the regression coefficients of determination were slightly improved for the entire region. Aggregation eliminated many dyads which reduced the model's explanatory power. However, the best results, with regard to explanation, were the regression on the individual ports to foreign countries.

This chapter has identified the explanatory variables which were statistically significant in explaining variance of container flows on various levels of the South Atlantic-Gulf coast region's container system. In the next chapter, these results will be compared with the original hypothesis and conclusions and recommendations will be made.

CHAPTER FIVE

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary

Chapter One began with an historical overview of container technology development and acceptance by the maritime transport industy. It traced the reasons for and the reluctance to accept this transport innovation. A description of the mechanics of containerized movements, which also included container types, was accomplished. Clearly, although containerization is today the major means for shipping general cargo, there is still a notable absence of spatial research concerning international container flows. Without a better statistical reporting system, geographers and other researhers will continue to be perplexed when attempting to understand the factors influencing container movements.

Also within Chapter One, the study's research goals were addressed. The goals were (1) to monitor changes in a portion of the world-wide container system and (2) to provide a quantitative analysis of the major factors affecting the container system. Following these goals, a working hypothesis was created. It stated that spatial interaction and spatial variation of a container system's flows could be explained by a modicum of variables. Nautical distance as well as various econometric variables alluded to in the literature were incorporated into the model.

The second chapter of the work introduced the concept of gravity models and their application with regard to trade flow description. A cross-sectional model was created to fit the empirical data to a least-squares regression analysis. Six independent variables were utilized. The function of the model was to propagate law-like statement(s). In order to simplify reality, so that the research could move from the specific to the general, six model assumptions were employed. Additionally, sources from which data were obtained were cited and the research methodology was defined.

In the descriptive analyses chapter, container flows emanating from the South Atlantic-Gulf coast region were examined for change. The examination was accomplished from the perspective of both domestic and foreign ports. On the domestic side, first the entire combined range was surveyed; secondly, the two ranges were viewed individually; and, finally the ports were examined as separate entities. From the foreign point of view, flows were considered at both the national and individual port level. The analyses were performed for each respective year of the study--1974 and 1976.

The final body of this work, the statistical analyses chapter, reported the results of the gravity/regression model. It also reviewed the various assumptions of regression analysis as applied to the port-to-country equations. In addition, it inspected the signs of the coefficients in the port-to-port models when all variables were forced to enter the equation, whether they were significant or not. This procedure allowed for an examination of the specific direction of the relationship between dependent and independent variables.

Conclusions

Study area domestic ports experienced a growth period from 1974 through 1976. However, ports in the South Atlantic range were more dynamic since they moved greater amounts of containerized cargo and sustained a greater absolute growth rate compared to ports in the Gulf range. Nevertheless, all domestic ports, except Mobile in Alabama and Tampa in Florida (for tonnage), increased their handle of cargo in containers. Foreign ports, led by the two European load centers of Rotterdam in the Netherlands and Bremerhaven in West Germany, generally also increased their container throughputs. However, although load centers were evident, diversification was indicated as many small volumes of containers flowed into various ports which did not handle containerized movements in 1974.

The thesis of the research, that although flows of international trade in maritime containers are dispersed world-wide, containerization will continue to be concentrated between and among industrialized economies rather than developing economies, was supported considering that over 80 percent of the two United States ranges' exports flowed to mature economies in 1974. However, this dominance decreased somewhat by 1976 to around 70 percent. The decrease, although not drastic, further demonstrated the spread of containerization and other unitized methods to all nations of the world regardless of their state of economy.

The overall performance of the gravity [illegible] model's ability to explain variance in container flows varied from low to moderate. In general, low coefficients of determination did not support rejecting

the null hypothesis and thus accepting the hypothesis that the spatial variations of a container system's flows could be explained by a modicum of variables. However, the inverse with regard to the hypothesis was not absolutely true.

It was deemed appropriate that the hypothesis could not be entirely rejected or accepted. Rather the model should be evaluated in a cautious manner since it supplied important general versus specific information. When the model was applied to regions of varying areal sizes, there was no apparent relationship between geographic extent and explanation provided except at the individual port level. In the majority of cases, the model's explanatory power was less in the latter study year. Reductions in capacity to account for flow variance most likely resulted because through time and growth the container system became more complex.

Initially, the gravity/regression model was applied to the combined ranges consisting of South Atlantic and Gulf ports. In the second instance, the model was used in an effort to explain variance of the two respective ranges individually. At the final stage, data were disaggregated on the basis of four domestic ports after completing the regressions in a port-to-country manner. Thus, the test reported results of five major areal models for the two years under consideration. Additionally, the port-to-country model was run with constraints on the minimum size of the dependent variable and also by eliminating flows to three nations which possess road carriers to attempt to improve explanation. Since the constrained models did not appreciably improve the model's ability to explain and predict, the

results were not extensively incorporated within the previous chapter, but rather cited in Appendices E and G.

The primary function of the research was to test whether qualitative variables embodied in the literature of containerization, after conversion to a quantitative set, could explain variance in South Atlantic-Gulf coast's containerized exports based upon port-to-port movements. In the first year of the study, total commerce in general cargo, followed by distance were statistically significant in partially explaining container flow variance. The contribution of volume of general cargo surely rests in the fact that ports in nations which historically, and even at present, handle large amounts of non-bulk traffic have a ready supply of containerizable freight. The significance of nautical distance confirms the effects and costs of overcoming the friction of distance in transport problems. However, by 1976, nautical distance was the primary factor adding to explanation and total commerce in general maritime cargo was no longer statisitcally significant. Instead, Gross National Product, energy per capita consumption, and number of commercial vehicles contributed to the remainder of explanation. The importance of Gross National Product and energy per capita resulted since high values of these variables are correlated favorably with well-developed industrialized economies and such economies contribute the majority of cargoes capable of being containerized. As stated in an earlier section, the entrance of the variable for commercial vehicles with a

negative coefficient resulted for one or more of the following reasons. These reasons included

(1) Because of the relatively small geographic size of most U.S. trading partners, only small fleets of land-based commercial vehicles were needed.

(2) Because load centers at foreign destinations transshipped many arriving cargoes and also because of inland barge services, motor trucking was not extensively utilized.

(3) Unit trains had diverted many cargoes which could have moved to inland destinations via trucking.

(4) Stripping and stuffing of containers was taking place within the confines of foreign ports.

The remaining equations served to discern and highlight differences in the explanatory power of the prescribed independent variables when the size of the domestic export area was changed. In these equations, the assumptions of least squared regression were addressed. The port-to-country models provided an increased degree of explanation compared to the port-to-port models.

In conclusion, differences were recorded with regard to the explanatory variables' contribution toward explanation in specific models. Even then, the amount of explanation offered by the gravity/regression model was moderate in most instances. Greater levels of explanation and model performance may result if in addition to the independent variables used, the model included endogenous variables which could be more influenced by the ports. In fact, the rapid spread of container innovation appears to have been more the product of industry

competitive pressures than of the system's economic return. Apparently, as containerization was accepted as a viable means for maritime general cargo transport by the developed economies, it was forced upon the developing economies. From the maritime industry point of view, first generation containerships were fitted with their own cargo handling gear; however, third and fourth generation vessels are not. Thus, costly container handling equipment, which was formerly the responsibility of the shipowners, is now a port amenity. Ports which do not or cannot provide container handling equipment are subject to cargo loss due to piracy or cargo capture by other ports. Thus, if a port wishes to increase or at least maintain its percentage share of general cargo; it must make substantial investments in port superstructure consisting of special cranes and other container handling equipment.

Recommendations

Although this research's statistical results were not as conclusive as one might have desired, they still presented an opportunity for hypothesis testing. The hypothesis that certain derived variables could lead to a better understanding of international container flows proved to be true to a limited extent. However, in most cases, the prescribed variables were unable to provide a majority of explanation.

Productive research should pose as many problems as it attempts to answer. In that right, various recommendations are made in order that future research can provide more definitive results. Future research directions, when attempting to comprehend the factors affecting the

magnitudes of container flows, will from necessity fall into three major categories of investigation:

(1) the geographic size and location of the study area;

(2) the exogenous explanatory variables; and

(3) the endogenous expanatory variables:

Further modeling of container flows should be directed toward individual port analyses. By disaggregating the data and examining them separately, certain characteristics unique to respective port facilities could be discovered. Another alternative could be to analyze the data on the trade route level. These types of analyses may produce benefits considering that some foreign trade areas require certain admixtures of general cargoes.

The problem generated by using only exogenous variables potentially could be overcome with the addition of untried variables. If data could be acquired and could be incorporated into the models which describe proximity to existing load centers, then the spillover effects of distribution hubs caused by the provision of feeder services could be accounted for. Other exogenous factors that should be considered include variables

(1) that reflect differential or preferential land transport freight rates and

(2) that measure freight forwarders preferences.

Use of differential and preferential freight rates would relax the fifth model assumption which stated that no special rate structures existed. Freight forwarders preferences have the ability of diverting cargoes away from a port s natural tributary area or hinterland.

Finally, endogenous factors--those which a port can directly influence--should be considered in future models. Vessel sailing schedules as well as their foreign ports of call play an important part in the decision making process of where shippers dispatch their goods. Investments in both port infrastructure and superstructure by port administrations have the ability of attracting additional carriers to a facility. Nevertheless, the single most important part that respective ports can play in assuring their future destinies are vigorous port promotion schemes to attract carriers and cargoes. However, without vessel callings and the revenues earned for the movement of cargoes across the land-water interface (wharfage), ports will not be able to survive.

APPENDIX A

IMPORTING COUNTRIES OF CONTAINERIZED CARGO
EXPORTED FROM SOUTH ATLANTIC AND GULF REGION,
1974 AND 1976

COUNTRY	1974 CONTAINERS	1974 TONS	1976 CONTAINERS	1976 TONS
Algeria	2	10	289	3,599
Angola	9	100		
Argentina	311	4,501	320	4,533
Australia	4,108	44,651	4,273	55,867
Bahamas	78	1,064		
Bahrain	1	5	33	1,223
Bangladesh			123	1,310
Barbados			594	6,875
Belgium	289	4,714	1,101	18,990
Bermuda	1,587	15,432		
Brazil	2,310	35,378	2,394	38,927
Cameroon			3	34
Canada	80	875	376	1,139
Chile	48	571	266	3,018
Colombia	151	2,603	428	4,864
Costa Rica	1,215	19,905	1,378	23,550
Dahomey			5	49
Denmark			171	2,978
Dominican Republic	746	11,050	343	4,209
Ecuador	110	1,423	1,622	19,984
Egypt			692	8,602
Ethiopia			226	2,389
Finland	50	567		
France	3,135	58,975	5,824	93,326
Gabon			1	7
Ghana	2	9	47	415
Greece	647	6,174	462	5,635
Grenada			39	205
Guadeloupe			2	25
Guatemala	225	3,791		
Haiti	871	11,894	997	11,977
Honduras	2,791	42,332	2,433	39,045
Hong Kong	1,087	16,539	4,145	62,915
India	24	428	240	2,550
Indonesia	168	1,669	43	524
Iran	11	104	101	1,965
Iraq			3	15
Ireland			23	340
Israel	367	5,966	649	9,461
Italy	1,394	19,945	6,743	104,195
Ivory Coast	1	113	13	320
Japan	9,895	168,580	12,399	261,045
Jordan			139	871

APPENDIX A (CONTINUED)

COUNTRY	1974 CONTAINERS	1974 TONS	1976 CONTAINERS	1976 TONS
Kenya	1	5		
Korea	347	5,239	707	15,076
Kuwait	22	122	17	302
Lebanon	6	42		
Liberia	64	901	22	330
Libya	4	11		
Malaysia	8	101	1	8
Martinique			28	356
Mexico	615	831		
Morocco	15	258	27	338
Mozambique	4	72		
Netherlands	33,291	455,800	48,129	791,185
Netherlands Antilles	980	14,247	2,267	36,657
New Zealand	342	6,044	1,121	16,746
Nigeria	21	197	912	15,957
Norway	39	586	2	49
Pakistan	16	16	88	791
Panama	209	2,035	136	1,515
Peru	58	475	140	1,080
Philippines	190	2,481	195	3,008
Poland			369	6,529
Saudi Arabia	39	205	1,612	24,791
Senegal			3	11
Singapore	488	5,128	1,715	22,140
Somalia	1	18		
South Africa	295	3,003	403	3,913
Spain	549	7,389	2,691	44,124
Srilanka	2	19	33	176
St. Vincent			248	4,251
Sudan			1	14
Surinam			3	28
Sweden	275	4,540	2	20
Tanzania	1	21	22	248
Thailand	35	428	15	199
Trinidad and Tobago			203	2,790
Tunisia			59	796
Turkey	104	525	306	4,005

APPENDIX A (CONTINUED)

COUNTRY	1974 CONTAINERS	1974 TONS	1976 CONTAINERS	1976 TONS
United Kingdom	6,841	119,967	5,489	90,176
Uruguay	20	274	83	1,095
West Germany	17,095	291,401	20,073	308,422
Venezuela	750	12,660	3,592	41,969
Zaire	14	204	13	252
TOTAL	94,653	1,423,698	138,762	2,176,736

Source: U.S. Department of Commerce, Maritime Administration, 1974 MARAD Containerized Foreign Trade Data, (unpublished report).

U.S. Department of Commerce, Maritime Administration, 1976 MARAD Containerized Foreign Trade Data, (unpublished report).

APPENDIX B

IMPORTING PORTS OF CONTAINERIZED CARGO EXPORTED FROM SOUTH ATLANTIC AND GULF REGION, 1974 AND 1976

COUNTRY	CITY	1974 CONTAINERS	1974 TONS	1976 CONTAINERS	1976 TONS
Algeria	Algiers			63	792
	Arzew	2	10	207	2,586
	Oran			19	221
Angola	Lobito	3	100		
Argentina	Buenos Aires	311	4,501	320	4,533
Australia	Adelaide	47	699	29	467
	Brisbane	124	1,329	325	4,535
	Fremantle	4	48	120	1,915
	Melbourne	2,109	23,103	1,932	26,163
	Sydney	1,824	19,676	1,867	22,787
Bahamas	Nassau	78	1,064		
Bahrain	Bahrain Island	1	5	33	1,223
Bangladesh	Chalna			1	4
	Chittagong			122	1,306
Barbados	Bridgetown			594	6,875
Belgium	Antwerp	359	4,714	1,093	18,821
	Ghent			8	169
Bermuda	Hamilton	1,587	15,432		
Brazil	Belem Para	4	60	8	91
	Fortaleza	1	12		
	Itaji	2,030	31,690	10	118
	Paranagua	24	330	25	317
	Recife	14	226	8	142
	Rio de Janeiro	177	2,733	632	10,405
	Rio Grande do Norte	16	150		
	Rio Grande do Sul	40	549	35	572
	Salvador	2	26	43	709
	Santos			1,633	26,573
Cameroon	Duala			3	34
Canada	Liverpool			29	408
	St John			347	731
	St. Johns	90	875		
Chile	Antofagasta	2	3	6	42
	Arica	1	7	10	94
	Coquimbo	10	69	4	26
	Iquique			1	3
	Valparaiso	35	493	245	2,853
Colombia	Barranquilla	61	1,391	204	2,216
	Buenaventura	80	1,152	89	1,194
	Cartegena	8	34	107	1,039
Costa Rica	Limon	1,215	19,905	1,378	23,550
Dahomey	Cotonou			5	49

APPENDIX B (CONTINUED)

COUNTRY	CITY	1974 CONTAINERS	1974 TONS	1976 CONTAINERS	1976 TONS
Denmark	Kobenhaven			165	2,898
	Odense			6	80
Dominican Republic	Santo Domingo	746	11,050	343	4,209
Ecuador	Guayequil	32	230	280	3,291
	Manta	78	1,193	1,342	16,693
Egypt	Alexandria			348	4,293
	Port Said			344	4,309
Ethiopia	Assab			226	2,389
Finland	Hamina	21	121		
	Helsinki	29	446		
France	Fos sur Mer	1	4	50	683
	Le Havre	3,128	58,908	5,429	86,239
	Marseille	6	63	345	6,404
Gabon	Libreville			1	7
Ghana	Takoradi			4	27
	Tema	2	9	43	388
Greece	Piraeus	546	6,164	462	5,635
	Thessalonika	1	10		
Grenada	St. Georges			39	205
Guadeloupe	Pointe-a-Pitre			2	25
Guatemala	Puerto Barrios	225	3,791		
Haiti	Port-au-Prince	671	11,894	997	11,977
Honduras	Limon	181	3,143	5	34
	Puerto Cortez	2,610	39,189	2,428	39,011
Hong Kong	Hong Kong	1,087	16,539	4,145	62,915
India	Bombay			123	1,326
	Calcutta			99	1,032
	Cochin	11	173	16	176
	Madras			2	16
	Shillong	13	255		
Indonesia	Balikpapan	41	535		
	Belawan	36	339	2	25
	Djakarta	81	669	26	361
	Jirebon	10	126		
	Surabaya			15	138
Iran	Abadan			3	400
	Bandare Shahpur			21	338
	Kharg Island			70	368
	Khorramshahr	11	104	7	759
Iraq	Basra			3	18
Ireland	Dublin			25	340
Israel	Ashdod	27	435	101	1,619
	Haifa	340	5,531	643	7,844
Italy	Genoa	785	11,702	1,516	27,066
	Livorno	331	4,389	3,672	70,044
	Naples	278	3,854	555	7,085

APPENDIX B (CONTINUED)

COUNTRY	CITY	1974 CONTAINERS	1974 TONS	1976 CONTAINERS	1976 TONS
Ivory Coast	Abidjan	1	113	19	320
Japan	Kobe	4,469	73,790	4,342	59,909
	Nagoya	91	1,644	635	10,023
	Osaka	26	553	20	363
	Tokyo	3,908	68,513	5,831	95,018
	Yokohama	1,401	24,320	1,571	35,732
Jordan	Aqaba			130	877
Kenya	Mombasa	1	5		
Korea	Inchon	28	353	97	1,245
	Pusan	319	4,886	610	13,831
Kuwait	Kuwait	22	122	17	302
Lebanon	Beirut	6	42		
Liberia	Buchanan	13	233		
	Monrovia	51	668	22	330
Libya	Benghazi	4	11		
Malaysia	Penang			1	8
	Port Swettenham	8	101		
Martinique	Fort-de-France			28	356
Mexico	Tuxpan	607	749		
	Veracruz	8	82		
Morocco	Casablanca	15	258	9	115
	Tangiers			16	223
Mozambique	Lorenco Marques	4	72		
Netherlands	Amsterdam	469	6,702	4	54
	Pernis	1	16		
	Rotterdam	32,821	449,082	48,125	791,131
Netherlands Antilles	Aruba	532	7,358	1,203	18,648
	Bonaire			12	232
	Curacao	448	6,889	1,048	17,776
New Zealand	Auckland	317	3,579	736	11,753
	Lyttleton			15	227
	Wellington	225	2,465	370	4,771
Nigeria	Apapa	14	118	511	9,263
	Lagos	3	27	381	6,442
	Port Harcourt	4	32	17	252
Norway	Oslo	35	515	2	46
	Stavanger	4	71		
Pakistan	Karachi	16	16	80	791
Panama	Almirante	31	76		
	Panama City	177	1,959	136	1,518
Peru	Callao	57	452	127	990
	Matarani	1	13	13	100
Philippines	Manila	190	2,481	185	3,308
Poland	Gdynia			369	6,529
Saudi Arabia	Damman	39	205	1,413	22,079
	Jidda			199	2,712

APPENDIX B (CONTINUED)

COUNTRY	CITY	1974 CONTAINERS	1974 TONS	1976 CONTAINERS	1976 TONS
Senegal	Dakar			3	11
Singapore	Singapore	488	5,128	1,715	22,140
Somalia	Baidoa	1	18		
South Africa	Capetown	33	230	48	466
	Durban	116	1,433	218	2,260
	East London	103	941	60	335
	Port Elizabeth	43	339	77	852
Spain	Barcelona	278	3,712	1,306	22,291
	Bilbao			67	942
	Cadiz	268	4,137	700	9,493
	Cartagena	1	4	18	210
	Valencia	2	36	600	11,188
Srilanka	Colombo	2	19	33	176
St. Vincent	Kingstown			248	4,251
Sudan	Port Sudan			1	14
Surinam	Paramaribo			3	28
Sweden	Goteborg	59	933	1	10
	Hoganas	2	36		
	Malmo	188	3,109		
	Norrkoping	19	353		
	Stockholm	7	109	1	10
Tanzania	Dar-es-Sallam	1	21	22	248
Thailand	Bangkok	35	428	15	199
Trinidad and Tobago	Pointe-a-Pierre			203	2,790
Tunisia	Bizerte			27	405
	Sfax			9	105
	Tunis			23	286
Turkey	Iskenderum			104	1,456
	Istanbul	69	321	162	2,123
	Izmir	35	204	38	410
	Mersin			2	16
United Kingdom	Belfast	2	35		
	Dagenham			3	24
	Felixstowe	762	7,883	249	2,954
	Glasgow	38	724		
	Greenock	5,369	101,623	2,308	47,224
	Liverpool	210	3,214		
	London	439	6,470	358	4,897
	Manchester	1	18		
	Preston			15	270
	Southampton			2,046	34,807

APPENDIX B (CONTINUED)

COUNTRY	CITY	1974 CONTAINERS	1974 TONS	1976 CONTAINERS	1976 TONS
Uruguay	Montevideo	20	274	88	1,095
Venezuela	Guanta			105	1,306
	La Guaira	349	2,582	2,433	27,663
	Maracaibo	16	322	284	3,121
	Puerto Cabello	385	9,756	565	6,656
	Puerto Sucre			205	3,223
West Germany	Bremen	391	5,204	207	3,504
	Bremerhaven	16,055	278,413	17,471	269,020
	Hamburg	649	7,784	2,395	35,898
Zaire	Matadi	14	204	18	252

Source: U.S. Department of Commerce, Maritime Administration, 1974 MARAD Containerized Foreign Trade Data, (unpublished report).

U.S. Department of Commerce, Maritime Administration, 1976 MARAD Containerized Foreign Trade Data, (unpublished report).

APPENDIX C

GEOCODES UTILIZED FOR SOUTH ATLANTIC AND GULF PORTS

STATE CODE	STATE	PORT CODE	PORT
01	Alabama	2100	Mobile
12	Florida	1050	Port Everglades
		1510	Jacksonville
		2010	Miami
		2450	Panama City
		2490	Pensacola
		2950	Tampa
13	Georgia	0760	Brunswick
		4910	Savannah
22	Louisiana	0150	Baton Rouge
		1250	Lake Charles
		1690	New Orleans
37	North Carolina	3120	Morehead City
		5060	Wilmington
45	South Carolina	0410	Charleston
48	Texas	0490	Beaumont
		1550	Corpus Christ
		2490	Beaumont
		2570	Galveston
		3280	Houston
		5100	Orange

Source: U.S. General Services Administration (1972) Worldwide Geographical Location Codes. Washington, D.C.: U.S. Government Printing Office.

APPENDIX D

GEOCODES UTILIZED FOR FOREIGN PORTS

COUNTRY CODE	COUNTRY	PORT CODE	PORT
125	Algeria	1000	Algiers
		6000	Oran
		9991	Arzew
141	Angola	4900	Lobito
150	Argentina	2000	Buenos Aires
160	Australia	0500	Adelaide
		1000	Brisbane
		2500	Freemantle
		5000	Melbourne
		7000	Sydney
180	Bahamas	5000	Nassau
181	Bahrain	2000	Bahrain Island
182	Bangladesh	2000	Chittagong
		9991	Chalna
184	Barbados	2100	Bridgetown
190	Belgium	1000	Antwerp
		2100	Ghent
195	Bermuda	2000	Hamilton
220	Brazil	2100	Blem Para
		4000	Fortaleza
		7000	Paranagua
		5100	Recife
		8200	Rio de Janeiro
		8300	Rio Grande do Norte
		9100	Salvador
		9200	Santos
		9991	Rio Grande do Sul
		9992	Itaji
257	Cameroon	1000	Doula
260	Canada	6650	St. John
		6700	St. Johns
		9992	Liverpool
272	Sri Lanka	2000	Colombo
275	Chile	1000	Antofagasta
		1500	Arica
		3600	Coquimbo
		9991	Inquique
285	Colombia	1000	Baranquilla
		2000	Buenventura
		3050	Cartegena
		7050	Santa Marta
291	Zaire	7500	Matadi

APPENDIX D (CONTINUED)

COUNTRY CODE	COUNTRY	PORT CODE	PORT
295	Costa Rica	5000	Limon
311	Dahomey	1500	Cotonou
315	Denmark	6000	Odense
		9991	Kobenhaven
320	Dominican Republic	8600	Santo Domingo
325	Ecuador	3000	Guayaquil
		4100	Manta
335	Ethiopia	1600	Assab
340	Finland	3000	Helsinki
		9991	Hamina
350	France	1950	Le Havre
		5400	Marseille
		9991	Fos sur Mer
388	Gabon	5000	Libreville
394	West Germany	2600	Cremen
		2825	Bremerhaven
		5500	Hamburg
396	Ghana	6900	Takoradi
		7075	Tema
400	Greece	4850	Piraeus
		6500	Thessalonika
406	Grenada	5900	St. Georges
407	Guadeloupe	5200	Pointe-a-Pitre
415	Guatemala	6000	Puerto Barrios
420	Haiti	7000	Port-au-Prince
430	Honduras	5000	Puerto Cortez
		9991	Limon
435	Hong Kong	3000	Hong Kong
455	India	2925	Bombay
		3000	Calcutta
		6000	Madras
		8000	Shillong
		9991	Cochin
458	Indonesia	0900	Balikpapan
		1200	Belawan
		3200	Djakarta
		8000	Surabaya
		9991	Jirebon
460	Iran	0100	Abadan
		0800	Bandare Shahpur
		2740	Khorramshahr
		9991	Kharg Island
465	Iraq	1500	Basra
470	Ireland	3000	Dublin

APPENDIX D (CONTINUED)

COUNTRY CODE	COUNTRY	PORT CODE	PORT
475	Israel	2000	Haifa
		9991	Ashod
480	Italy	3000	Genoa
		4200	Livorno
		5500	Naples
485	Ivory Coast	1000	Abidjan
490	Japan	4500	Kobe
		5050	Nagoya
		5800	Osaka
		8000	Tokyo
		9400	Yokohama
500	Jordan	9991	Aqaba
505	Kenya	4000	Mombasa
515	Korea	4000	Inchon
		6500	Pusan
520	Kuwait	2000	Kuwait
540	Lebanon	2000	Beirut
545	Liberia	1150	Buchanan
		6000	Monrovia
550	Libya	2100	Benghazi
580	Malaysia	6000	Penang
		6200	Port Swettenham
591	Martinique	3000	Fort-de-France
595	Mexico	7600	Tuxpan
		8000	Vera Cruz
610	Morocco	3000	Casablanca
		6000	Tangier
615	Mozambique	5000	Lourenco Marques
630	Netherlands	1000	Amsterdam
		7000	Rotterdam
		9991	Pernis
640	Netherlands Antilles	1000	Aruba
		3000	Curacao
		9991	Bonaire
660	New Zealand	1000	Auckland
		9500	Wellington
		9992	Lyttleton
670	Nigeria	0225	Apapa
		5000	Lagos
		7000	Port Harcourt
685	Norway	6000	Oslo
		8000	Stavanger
700	Pakistan	4000	Karachi
710	Panama	0700	Panama City
		9991	Almirante

APPENDIX D (CONTINUED)

COUNTRY CODE	COUNTRY	PORT CODE	PORT
720	Peru	1500	Callao
		5500	Matarani
725	Philippines	3800	Manila
730	Poland	6000	Gdynia
775	St. Vincent	3600	Kingstown
785	Saudi Arabia	1000	Damman
		4000	Jidda
787	Senegal	2000	Dakar
795	Singapore	1000	Singapore
800	Somalia	1000	Baidoa
801	South Africa	2000	Capetown
		3000	Durban
		7000	Port Elizabeth
		9991	East London
830	Spain	1000	Barcelona
		1400	Bilbao
		1600	Cadiz
		1900	Cartagena
		8000	Valencia
835	Sudan	6000	Port Sudan
840	Surinam	5000	Paramaribo
850	Sweden	3000	Goteborg
		6000	Malmo
		6500	Norrkoping
		8000	Stockholm
		9992	Hoganas
865	Tanzania	2000	Dar-es-Sallam
875	Thailand	2000	Bangkok
887	Trinadad and Tobago	5500	Pointe-a-Pierre
890	Tunisia	2000	Bizerte
		8000	Tunis
		9991	Sfax
905	Turkey	4500	Iskenderum
		4600	Istanbul
		4950	Izmir
		6000	Mersin
922	Egypt	1000	Alexandria
		7001	Port Said

APPENDIX D (CONTINUED)

COUNTRY CODE	COUNTRY	PORT CODE	PORT
925	United Kingdom	0400	Belfast
		4200	Glasgow
		4450	Greenock
		5400	Liverpool
		5600	London
		6000	Manchester
		5400	Southampton
		9991	Felixstowe
		9992	Dagenham
		9993	Preston
930	Uruguay	6000	Montevideo
940	Venezuela	3500	Guanta
		5000	La Guaira
		6000	Maracaibo
		9991	Puerto Cabello
		9992	Puerto Sucre

Source: U.S. General Services Administration (1972) Worldwide Geographical Location Codes. Washington, D.C.: U.S. Government Printing Office.

APPENDIX E

CONSTRAINED GRAVITY MODELS, 19[illegible]

South Atlantic-Gulf

Constrained for NCTNX greater than 50 and COUNTRY except 630

$$\log NCTNX = 5.30 + \underset{(4.48)}{0.61} \log RITE$$

$R = 0.22 \quad \bar{R}^2 = 0.04 \quad F = 4.48 \quad n = 80$

$$\log NTNSX = 6.73 + \underset{(4.38)}{0.16} \log GNP$$

$R = 0.22 \quad \bar{R}^2 = 0.04 \quad F = 4.38 \quad n = 80$

Constrained for NCTNX greater than 50 and Country except 630 and 394

$$\log NCTNX = 4.92 + \underset{(9.73)}{0.83} \log RITE$$

$R = 0.35 \quad \bar{R}^2 = 0.11 \quad F = 9.73 \quad n = 71$

$$\log NTNSX = 7.35 + \underset{(7.54)}{0.91} \log RITE$$

$R = 0.32 \quad \bar{R}^2 = 0.09 \quad F = 7.54 \quad n = 71$

Constrained for NCTNX greater than 50 and Country except 630, 394 and 490

$$\log NCTNX = 4.97 + \underset{(7.08)}{0.75} \log RITE$$

$R = 0.32 \quad \bar{R}^2 = 0.09 \quad F = 7.08 \quad n = 65$

$$\log NTNSX = 7.43 + \underset{(4.72)}{0.78} \log RITE$$

$R = 0.26 \quad \bar{R}^2 = 0.06 \quad F = 4.72 \quad n = 65$

APPENDIX A

REGRESSION ANALYSES OF THE SOUTH ATLANTIC-GULF COAST'S MAJOR PORTS, 1974

Charleston, South Carolina

Regression

$$\log NCTNX = -10.69 + 1.51 \log TCM \quad (0.2462)$$

$\bar{R}^2 = 0.6135$ F = 37.51 S = 1.6001 n = 24

Sorted on logTCM

lower sample: $\log NCTNX = -17.43 + 2.29 \log TCM \quad (1.0683)$

$\bar{R}^2 = 0.2843$ F = 4.58 S = 1.8090 n = 10

upper sample: $\log NCTNX = -14.27 + 1.82 \log TCM \quad (0.5907)$

$\bar{R}^2 = 0.4831$ F = 9.41 S = 1.4526 n = 10

Residual Sum of Squares

$(n-2)S_1^2 = 26.1801$

$(n-2)S_2^2 = 16.8797$

computed F = 1.5510

tabulated F = 3.4381

APPENDIX F (CONTINUED)

Charleston, South Carolina

Regression

$$\log NTNSX = -9.98 + 1.67 \log TCM \quad (0.2780)$$

$\bar{R}^2 = 0.6028$ F = 35.90 S = 1.8078 n = 24

Sorted on logTCM

lower sample: $\log NTNSX = -18.12 + 2.60 \log TCM \quad (1.2461)$

$\bar{R}^2 = 0.2710$ F = 4.35 S = 2.1101 n = 10

upper sample: $\log NTNSX = -12.26 + 1.86 \log TCM \quad (0.6009)$

$\bar{R}^2 = 0.4869$ F = 9.54 S = 1.4777 n = 10

Residual Sum of Squares

$(n-2)S_1^2 = 35.6204$

$(n-2)S_2^2 = 17.4689$

computed F = 2.0391

tabulated F = 3.4381

APPENDIX F (CONTINUED)

Miami, Florida

Regression

$$\log NCTNX = 20.49 - 2.06 \log DST \quad (0.3648)$$

$\bar{R}^2 = 0.6317$ F = 31.88 S = 1.4876 n = 19

Sorted on logDST

lower sample: $\log NCTNX = 9.90 - 0.53 \log DST \quad (2.1346)$

$\bar{R}^2 = -0.1547$ F = 0.06 S = 1.2150 n = 8

upper sample: $\log NCTNX = 30.40 - 3.19 \log DST \quad (1.6059)$

$\bar{R}^2 = 0.2959$ F = 3.94 S = 1.9899 n = 8

Residual Sum of Squares

$(n-2)S_1^2 = 8.8577$

$(n-2)S_2^2 = 23.7581$

computed F = 2.6822

tabulated F = 4.2839

APPENDIX F (CONTINUED)

Miami, Florida

Regression

$$\log NTNSX = 23.97 - 2.19 \log DST \quad (0.4409)$$

$\overline{R^2} = 0.5683$ F = 24.69 S = 1.7981 n = 19

Sorted on logDST

lower sample: $\log NTNSX = 17.99 - 1.34 \log DST \quad (2.0051)$

$\overline{R^2} = -0.0857$ F = 0.45 S = 1.1413 n = 8

upper sample: $\log NTNSX = 32.75 - 3.19 \log DST \quad (2.1378)$

$\overline{R^2} = 0.1493$ F = 2.23 S = 2.6490 n = 8

Residual Sum of Squares

$(n-2)S_1^2 = 7.8156$

$(n-2)S_2^2 = 42.1040$

computed F = 5.3872

tabulated F = 4.2839

APPENDIX F (CONTINUED)

Miami, Florida

Regression

$$\log NTNSX/\log DST = 2.14/\log DST + 23.56 \log DST/\log DST \quad (3.2903)$$

$\overline{R^2} = 0.7366$ F = 51.34 S = 0.2207 n = 19

Sorted on logDST

lower sample: $\log NTNSX/\log DST = -1.42/\log DST + 18.53 \log DST/\log DST \quad (13.6172)$

$\overline{R^2} = 0.1086$ F = 1.85 S = 0.1672 n = 8

upper sample: $\log NTNSX/\log DST = -3.30/\log DST + 33.30 \log DST/\log DST \quad (19.1219)$

$\overline{R^2} = 0.2313$ F = 3.11 S = 0.3074 n = 8

Residual Sum of Squares

$(n-2)S_1^2 = 0.1676$

$(n-2)S_2^2 = 0.5670$

computed F = 3.3831

tabulated F = 4.2839

APPENDIX F (CONTINUED)

New Orleans, Louisiana

Regression

$$\log NCTNX = -5.52 + 0.93 \log TCM \quad (0.1851)$$

$\bar{R}^2 = 0.3492$ F = 25.15 S = 1.5139 n = 46

Sorted on logTCM

lower sample: $\log NCTNX = -0.85 + 0.38 \log TCM \quad (0.4166)$

$\bar{R}^2 = -0.0079$ F = 0.84 S = 1.6886 n = 21

upper sample: $\log NCTNX = -16.60 + 1.93 \log TCM \quad (0.5157)$

$\bar{R}^2 = 0.3946$ F = 14.04 S = 1.8423 n = 21

Residual Sum of Squares

$(n-2)S_1^2 = 54.1779$

$(n-2)S_2^2 = 64.4908$

computed F = 1.1904

tabulated F = 2.1712

APPENDIX F (CONTINUED)

New Orleans, Louisiana

Regression

$$\log NTNSX = -4.10 + 1.02 \log TCM \quad (0.2142)$$

$\bar{R}^2 = 0.3301$ F = 23.17 S = 2.0804 n = 46

Sorted on logTCM

lower sample: $\log NTNSX = 1.37 + 0.38 \log TCM \quad (0.4901)$

$\bar{R}^2 = -0.0202$ F = 0.60 S = 1.9865 n = 21

upper sample: $\log NTNSX = -15.61 + 2.07 \log TCM \quad (0.5898)$

$\bar{R}^2 = 0.3608$ F = 12.29 S = 2.2072 n = 21

Residual Sum of Squares

$(n-2)S_1^2 = 74.9757$

$(n-2)S_2^2 = 84.3641$

computed F = 1.1285

tabulated F = 2.1712

APPENDIX F (CONTINUED)

Savannah, Georgia

Regression

$$\log NCTNX = -10.96 + \underset{(0.3637)}{0.98}\log DST + \underset{(0.2474)}{1.07}\log EGY$$

$\bar{R}^2 = 0.4780$ F = 10.16 S = 1.2524 n = 21

Sorted on logEGY

lower sample: $\log NCTNX = -2.33 - \underset{(1.2954)}{0.17}\log DST + \underset{(0.4499)}{1.25}\log EGY$

$R^2 = 0.4292$ F = 4.01 S = 1.2695 n = 9

upper sample: $\log NCTNX = 7.11 + \underset{(0.4300)}{0.92}\log DST - \underset{(0.7675)}{0.92}\log EGY$

$\bar{R}^2 = 0.6047$ F = 7.14 S = 0.9133 n = 9

Residual Sum of Squares

$(n-3)S_1^2 = 9.6691$

$(n-3)S_2^2 = 5.0601$

computed F = 1.9109

tabulated F = 4.2839

APPENDIX F (CONTINUED)

Savannah, Georgia

Regression

$$\log NTNSX = -2.80 + 0.51 \log TCM + 0.69 \log EGY$$
$$(0.2320) \quad (0.3102)$$

$\bar{R}^2 = 0.3983$ F = 7.62 S = 1.5711 n = 21

Sorted on logEGY

lower sample: $\log NTNSX = 9.33 + 1.06 \log TCM - 0.31 \log EGY$
(0.3462) $(0.4[illegible])$

$\bar{R}^2 = 0.3013$ F = 2.72 S = 1.6899 n = 9

upper sample: $\log NTNSX = 17.84 + 0.69 \log TCM - 1.91 \log EGY$
(0.2300) (0.5348)

$\bar{R}^2 = 0.7417$ F = 12.49 S = 0.7937 n = 9

Residual Sum of Squares

$(n-3)S_1^2 = 17.1321$

$(n-3)S_2^2 = 3.7798$

computed F = 4.5325

tabulated F = 4.2839

APPENDIX F (CONTINUED)

Savannah, Georgia

Regression

$$\log NTNSX\log EGY = -3.9\log EGY + 0.56\log TCM\log EGY + 0.34\log^2 EGY$$
$$(0.2357) \qquad (0.2746)$$

$\bar{R}^2 = 0.6263$ F = 17.76 S = 12.6231 n = 21

Sorted on logEGY

lower sample:

$$\log NTNSX\log EGY = -25.59\log EGY + 1.06\log TCM\log EGY + 0.01\log^2 EGY$$
$$(0.8998) \qquad (0.9043)$$

$\bar{R}^2 = 0.4795$ F = 4.68 S = 12.4482 n = 9

upper sample:

$$\log NTNSX\log EGY = 83.38\log EGY + 0.67\log TCM\log EGY - 0.94\log^2 EGY$$
$$(0.2311) \qquad (0.2851)$$

$\bar{R}^2 = 0.5925$ F = 6.82 S = 6.9869 n = 9

Residual Sum of Squares

$(n-3)S_1^2 = 929.7490$

$(n-3)S_2^2 = 292.9004$

computed F = 3.1743

tabulated F = 4.2839

APPENDIX G

CONSTRAINED GRAVITY MODELS, 1976

South Atlantic-Gulf

Constrained for NCTNX greater than 50 and COUNTRY except 630

$$\log NCTNX = 7.49 - 0.73 \log DST + 0.42 \log TCM + 0.53 \log RITE$$
$$(18.81) \qquad (36.53) \qquad (4.05)$$

$R = 0.56 \quad \bar{R}^2 = 0.31 \quad F = 15.22 \quad n = 107$

$$\log NTNSX = 9.40 - 0.65 \log DST + 0.46 \log TCM$$
$$(12.60) \qquad (33.17)$$

$R = 0.51 \quad \bar{R}^2 = 0.26 \quad F = 18.09 \quad n = 107$

Constrained for NCTNX greater than 50 and COUNTRY except 630 and 394

$$\log NCTNX = 7.55 - 0.69 \log DST + 0.38 \log TCM + 0.34 \log RITE$$
$$(18.16) \qquad (23.36) \qquad (4.78)$$

$R = 0.54 \quad \bar{R}^2 = 0.29 \quad F = 12.85 \quad n = 98$

$$\log NTNSX = 9.42 - 0.61 \log DST + 0.41 \log TCM$$
$$(11.29) \qquad (25.13)$$

$R = 0.48 \quad \bar{R}^2 = 0.23 \quad F = 14.02 \quad n = 98$

Constrained for NCTNX greater than 50 and COUNTRY except 630, 394 and 490

$$\log NCTNX = 8.10 - 0.69 \log DST + 0.32 \log TCM + 0.31 \log RITE$$
$$(19.29) \qquad (19.46) \qquad (4.10)$$

$R = 0.51 \quad \bar{R}^2 = 0.26 \quad F = 10.44 \quad n = 95$

$$\log NTNSX = 10.16 - 0.63 \log DST + 0.35 \log TCM$$
$$(12.44) \qquad (16.47)$$

$R = 0.44 \quad \bar{R}^2 = 0.19 \quad F = 11.02 \quad n = 95$

APPENDIX H

REGRESSION ANALYSES OF THE SOUTH ATLANTIC-GULF COAST'S MAJOR PORTS, 1976

Charleston, South Carolina

Regression

$$\log NCTNX = -0.06 - \underset{(0.3992)}{1.08}\log DST + \underset{(0.2348)}{1.41}\log TCM$$

$\bar{R}^2 = 0.5283$ F = 18.92 S = 1.7469 n = 33

Sorted on logTCM

lower sample: $\log NCTNX = 7.27 - \underset{(0.5405)}{0.73}\log DST + \underset{(0.7600)}{0.18}\log TCM$

$\bar{R}^2 = 0.0012$ F = 1.01 S = 1.8415 n = 14

upper sample: $\log NCTNX = 10.55 - \underset{(0.5610)}{1.91}\log DST + \underset{(0.4008)}{1.12}\log TCM$

$\bar{R}^2 = 0.5633$ F = 6.99 S = 1.1187 n = 14

Residual Sum of Squares

$(n-3)S_1^2 = 37.3041$

$(n-3)S_2^2 = 13.7671$

computed F = 2.7097

tabulated F = 2.3206

APPENDIX H (CONTINUED)

Charleston, South Carolina

Regression

$$\log NTNSX = 1.60 - 1.28 \log DST + 1.66 \log TCM$$
$$(0.4625) \quad (0.2720)$$

$\bar{R}^2 = 0.5375$ F = 19.60 S = 2.0238 n = 33

Sorted on logTCM

lower sample: $\log NTNSX = 9.40 - 1.03 \log DST + 0.46 \log TCM$
$(0.6764) \quad (0.9511)$

$\bar{R}^2 = 0.0281$ F = 1.19 S = 2.3045 n = 14

upper sample: $\log NTNSX = 12.37 - 1.94 \log DST + 1.23 \log TCM$
$(0.6283) \quad (0.4563)$

$\bar{R}^2 = 0.5165$ F = 7.94 S = 1.2737 n = 14

Residual Sum of Squares

$(n-3)S_1^2 = 58.4158$

$(n-3)S_2^2 = 17.8454$

computed F = 3.2734

tabulated F = 2.8206

APPENDIX H (CONTINUED)

Charleston, South Carolina

Regression

$$\log NTNSX\log TCM = 9.00\log TCM - 1.32\log DST\log TCM + 1.78\log^2 TCM$$
$$(0.4739) \qquad (0.2535)$$

$\bar{R}^2 = 0.7305$ F = 44.36 S = 19.3770 n = 33

Sorted on logTCM

lower sample:

$$\log NTNSX\log TCM = 39.45\log TCM + 1.06\log DST\log TCM + 0.05\log^2 TCM$$
$$(0.7437) \qquad (0.7426)$$

$\bar{R}^2 = 0.0164$ F = 1.11 S = 20.9142 n = 14

upper sample:

$$\log NTNSX\log TCM = 66.48\log TCM - 1.92\log DST\log TCM + 1.78\log^2 TCM$$
$$(0.6380) \qquad (0.3356)$$

$\bar{R}^2 = 0.6872$ F = 15.28 S = 13.8564 n = 14

Residual Sum of Squares

$(n-3)S_1^2 = 4211.4201$

$(n-3)S_2^2 = 2112.0024$

computed F = 2.2781

tabulated F = 2.8206

APPENDIX H (CONTINUED)

Miami, Florida

Regression

$$\log NCTNX = 15.29 - 1.42 \log DST \quad (0.4108)$$

$\overline{R}^2 = 0.2746$ F = 11.98 S = 2.0446 n = 30

Sorted on logDST

lower sample: $\log NCTNX = 14.68 - 1.32 \log DST \quad (2.2273)$

$\overline{R}^2 = -0.0572$ F = 0.35 S = 2.4045 n = 13

upper sample: $\log NCTNX = 17.71 - 1.67 \log DST \quad (0.8982)$

$\overline{R}^2 = 0.1707$ F = 3.47 S = 1.5870 n = 13

Residual Sum of Squares

$(n-2)S_1^2 = 63.5988$

$(n-2)S_2^2 = 27.7032$

computed F = 2.2957

tabulated F = 2.8206

APPENDIX H (CONTINUED)

Miami, Florida

Regression

$$\log NTNSX = 18.70 - 1.56 \log DST \quad (0.4226)$$

$\bar{R}^2 = 0.3032$ F = 13.61 S = 2.1031 n = 30

Sorted on logDST

lower sample: $\log NTNSX = 23.72 - 2.20 \log DST \quad (2.2238)$

$\bar{R}^2 = 0.0026$ F = 1.02 S = 2.4008 n = 13

upper sample: $\log NTNSX = 22.24 - 1.93 \log DST \quad (0.9545)$

$\bar{R}^2 = 0.2046$ F = 4.09 S = 2.6865 n = 13

Residual Sum of Squares

$(n-2)S_1^2 = 63.3998$

$(n-2)S_2^2 = 31.2873$

computed F = 2.0264

tabulated F = 2.8206

APPENDIX H (CONTINUED)

New Orleans, Louisiana

Regression

$$\log NCTNX = 5.97 - 0.86 \log DST + 0.52 \log GNP$$
$$(0.4744) \quad (0.1661)$$

$$\bar{R}^2 = 0.2076 \quad F = 7.58 \quad S = 1.8275 \quad n = 52$$

Sorted on logGNP

lower sample: $\log NCTNX = 9.02 - 0.88 \log DST + 0.13 \log GNP$
$(0.4590) \quad (0.3686)$

$$\bar{R}^2 = 0.1177 \quad F = 1.94 \quad S = 1.5118 \quad n = 24$$

upper sample: $\log NCTNX = 1.20 - 0.34 \log DST + 0.77 \log GNP$
$(1.0945) \quad (0.4891)$

$$\bar{R}^2 = 0.0914 \quad F = 1.58 \quad S = 2.3757 \quad n = 24$$

Residual Sum of Squares

$(n-3)S_1^2 = 47.9963$

$(n-3)S_2^2 = 94.6370$

computed F = 1.9716

tabulated F = 2.2243

APPENDIX H (CONTINUED)

New Orleans, Louisiana

Regression

$$\log NTNSX = 3.60 - \underset{(0.4657)}{0.93}\log DST + \underset{(0.1713)}{0.57}\log GNP$$

$\overline{R}^2 = 0.2056$ F = 7.60 S = 2.0166 n = 52

Sorted on logGNP

lower sample: $\log NTNSX = 12.98 - \underset{(0.4837)}{1.07}\log DST + \underset{(0.3884)}{0.19}\log GNP$

$\overline{R}^2 = 0.1592$ F = 2.56 S = 1.5929 n = 24

upper sample: $\log NTNSX = 1.20 - \underset{(1.0945)}{0.34}\log DST + \underset{(0.4891)}{0.77}\log GNP$

$\overline{R}^2 = 0.0914$ F = 1.58 S = 2.3757 n = 24

Residual Sum of Squares

$(n-3)S_1^2 = 53.2861$

$(n-3)S_2^2 = 118.5232$

computed F = 2.2243

tabulated F = 2.0855

APPENDIX H (CONTINUED)

New Orleans, Louisiana

Regression

$$\log NTNSX/\log GNP = 0.52/\log GNP - 1.03\log DST/\log GNP \quad (0.3101)$$
$$+ 9.93\log GNP/\log GNP \quad (3.8557)$$

$\bar{R}^2 = 0.0853$ F = 3.38 S = 0.2055 n = 52

Sorted on logGNP

lower sample:

$$\log NTNSX/\log GNP = 0.15/\log GNP - 1.13\log DST/\log GNP \quad (0.4796)$$
$$+ 13.76\log GNP/\log GNP \quad (5.1447)$$

$\bar{R}^2 = 0.2240$ F = 3.64 S = 0.2020 n = 24

upper sample:

$$\log NTNSX/\log GNP = 0.87/\log GNP - 0.28\log DST/\log GNP \quad (1.0338)$$
$$- 0.27\log GNP/\log GNP \quad (11.8749)$$

$\bar{R}^2 = -0.0229$ F = 0.23 S = 0.2062 n = 24

Residual Sum of Squares

$(n-3)S_1^2 = 0.8570$

$(n-3)S_2^2 = 0.8920$

computed F = 1.0408

tabulated F = 2.0855

APPENDIX H (CONTINUED)

Savannah, Georgia

Regression

$$\log NCTNX = 6.52 - 1.60 \log DST + 1.13 \log GNP$$
$$(0.6270) \quad (0.2144)$$

$\bar{R}^2 = 0.5225$ F = 19.05 S = 1.7700 n = 43

Sorted on logGNP

lower sample: $\log NCTNX = 11.95 - 0.49 \log DST - 0.59 \log GNP$
$(1.0237) \quad (0.8726)$

$\bar{R}^2 = -0.0691$ F = 0.55 S = 2.0581 n = 15

upper sample: $\log NCTNX = 7.71 - 1.76 \log DST + 1.16 \log GNP$
$(0.9633) \quad (0.4324)$

$\bar{R}^2 = 0.5245$ F = 8.72 S = 1.4205 n = 15

Residual Sum of Squares

$(n-3)S_1^2 = 50.8284$

$(n-3)S_2^2 = 24.2146$

computed F = 2.0991

tabulated F = 2.6866

APPENDIX H (CONTINUED)

Savannah, Georgia

Regression

$$\log NTNSX = 9.23 - 1.77 \log DST + 1.23 \log GNP$$
$$(0.7326) \quad (0.2505)$$

$\bar{R}^2 = 0.4873$ F = 16.68 S = 2.0682 n = 34

Sorted on logGNP

lower sample: $\log NTNSX = 14.12 - 0.29 \log DST - 0.79 \log GNP$
$(1.1871) \quad (1.0119)$

$\bar{R}^2 = -0.8060$ F = 0.48 S = 2.3866 n = 15

upper sample: $\log NTNSX = 15.61 - 2.60 \log DST + 1.31 \log GNP$
$(1.1011) \quad (0.4942)$

$\bar{R}^2 = 0.5791$ F = 10.63 S = 1.6237 n = 15

Residual Sum of Squares

$(n-3)S_1^2 = 68.3514$

$(n-3)S_2^2 = 31.6351$

computed F = 2.1606

tabulated F = 2.6866

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BIOGRAPHICAL SKETCH

Bruce E. Marti was born in Brooklyn, New York in 1943. In 1961, he was graduated from Memorial High School in West New York, New Jersey. His undergraduate studies were conducted at New Mexico State Univeristy, from which he received a Bachelor ofScience in 1967. In 1968, he was drafted into the U.S. Army and served in Korea until 1970. During and after baccalaureate degree studies, he worked intermittently in the United States Merchant Marines as an unlicensed seaman. In 1975, he completed his Master of Arts degree at Florida Atlantic University. One year later, he entered the University of Florida to complete the degree of Doctor of Philosophy. He was the first student in the State of Florida to matriculate in a joint Ph.D. program in geography which involved the University of Florida, Florida State University and Florida Atlantic University. After being admitted to candidacy, he was employed at PLANTEC Corporation, in Jacksonville, Florida as a senior socioeconomist. In 1980, he accepted a faculty position at the University of Rhode Island in the Department of Geography and Marine Affairs as a maritime transport/port specialist. Early in 1982 he was married.

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

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